UNIVERSAL
LIBRARY
OU_168398
UNIVERSAL
LIBRARY

THE "CHEMICAL AGE" CHEMICAL DICTIONARY

THE "CHEMICAL AGE" CHEMICAL DICTIONARY

CHEMICAL TERMS

LONDON: ERNEST BENN LIMITED
8, BOUVERIE STREET, E.C.4
1924

Printed by Jarrold & Sons, Limited, Norwich

PREFACE

THE vast output of chemical literature at the present time is presenting almost insuperable difficulties to those who attempt to keep abreast of the rapid advances in chemical science. Not the least of these difficulties is the terminology of the subject, for chemical terms are multiplying at a bewildering rate. Frequently, too, when a new word or expression is coined it is followed up with an abbreviation or symbol by which it is expressed. One has, in fact, only to glance through the abstracts of the English and American Chemical Societies to realise the difficulty.

The Chemical Age Dictionary of Chemical Terms has been compiled by experts to meet the needs of all those who have to consult not only original papers or their abstracts but other forms of literature as represented by reviews and modern textbooks. It will, therefore, make a direct appeal to all chemists from the student to the director of research.

The subjects dealt with include organic, inorganic, physical, analytical and biochemistry.

Unfortunately, many chemical terms are loose and even vague and it is very difficult, if not impossible, to give exact definitions in such cases. Indeed, it is undesirable to attempt to give an exact definition where none exists This is especially the case with names by which certain "theories" or "concepts" are known. In general the terms will be found in the form in which they are most frequently met with in technical literature, but in order to avoid repetition it has been found convenient in some cases to include a number of closely related terms under one general term. Thus, the different types of isomerism are classed together under "Isomerism," the different kinds of spectra under "Spectrum," and so on. The many "laws," "reactions," etc., are not grouped together under these headings but will be found under the names by which they are known For example "Henry's Law," and not "Law of Henry," "Hoesch Reaction," and not "Reaction, Hoesch" "van't Hoff factor" and not "Factor, van't Hoff."

In many cases cross-references are given not only to the same subject but to cognate subjects. No effort has been spared to illustrate the explanations and definitions by means of examples; and it is hoped that these will be of great assistance in elucidating terms which could not otherwise be made perfectly clear. The Dictionary is an essential supplement to, but not a substitute for, the textbook.

The present dictionary is intended to be the forerunner of successive volumes, each one of which will deal with the subject as it appears in its different phases. Thus, it is hoped to publish a second volume dealing with "Organic Substances," a third dealing with "Inorganic Substances," etc.

No Dictionary compiled on similar lines has as yet appeared in the English language. It is hoped, therefore, that the present volume will prove not only a novelty, but an indispensable companion for all those who are interested in pure chemistry or its application to industry.

LONDON

September, 1924

CONTENTS

	PAGE
PREFACE	5
A	9
B	24
C	30
D	45
E	56
F	64
G	69
H	74
I	82
J	92
K	92
L	94
M	97
N	106
O	111
P	117
Q	128
R	130
S	135
T	145
U	151
V	152
W	154
X	155
Z	156
TABLE OF SYMBOLS	157

THE "CHEMICAL AGE" CHEMICAL DICTIONARY: CHEMICAL TERMS

A

Absolute Zero.—The temperature $-273°$ centigrade. Temperatures measured from this zero are termed *absolute temperatures* and are generally designated by a capital T If t° is the temperature centigrade then $T° = 273 + t°$.

Absorptiometer.—An apparatus for determining the solubility of gases in liquids. It consists of a graduated vessel containing the liquid and a known volume of gas; or the absorption may be done in a separate vessel, the gas being measured out from a burette There are several modifications of these types. They are also used in gas analysis, the gas being absorbed by a substance with which it reacts. *See* Hempel Apparatus.

Absorption.—A physical process in which one or more substances are taken up by some other substance, as, *e.g.* gases in liquids and solids, and liquids in solids. *See* Sorption and Adsorption.

Absorption Coefficient.—*See* Henry's Law.

Absorption Coefficient (Light).—The absorption of light rays by a solution may be expressed by the equation

$$I = I_0 e^{-hcd},$$

where I_0 is the original intensity of the light, I the intensity after passing through a thickness *d* of the solution of concentration *c*, *k* is a constant known as the absorption coefficient, and *e* the base of the natural logarithms. *Cf.* Beer's Law, and Absorption Coefficient (X-ray).

Absorption Coefficient (X-ray).—The constant *k* in the X-ray absorption equation

$$I = I_0 e^{-kd},$$

where I_0 is the original intensity of the X-rays and I the intensity after passing through the thickness *d* of substance. *See* X-rays, X-ray Spectrum, X-ray Analysis.

Absorption (General).—*See* Spectrum, Absorption.

Absorption Law.—*See* Henry's Law.

Absorption (Selective).—*See* Spectrum, Absorption.

Absorption Spectrum.—*See* Spectrum, Absorption.

Ac.—*See* Acetyl.

Acceptor.—*See* Induced Reactions.

Accessory Factors (Diet).—Constituents of foods, present only in minute amount, which are required in order that a diet, otherwise sufficient for the supply of energy and material, may be adequate for growth or for maintenance of health. *See* Vitamins.

Acclimatisation (Colloid).—When a quantity of precipitating agent sufficient, if added all at once, to precipitate a colloidal sol is added slowly it is frequently found that precipitation is incomplete and a larger quantity of the precipitant is required for complete precipitation. The colloid is said to have become acclimatised to the particular precipitant.

Acetalisation.—*See* Acetals.

Acetals.—Compounds of the type

$$R\,CH\langle^{OR}_{OR} \text{ or } R_2C\langle^{OR}_{OR}$$

where R is an alkyl radical. They are formed from a molecule of aldehyde or ketone and two molecules of an alcohol (generally C_2H_5OH), *e.g.*

$$CH_3.CHO + 2C_2H_5OH \rightarrow CH_3.CH(OC_2H_5)_2$$

acetal

The reaction is termed acetalisation. *See* Ethers, Cycloacetals, and Aldehydrols.

Acetenyl (Radical).—The group $CH \equiv C-$.

Aceto-.—*See* Acetyl.

Acetolysis.—The splitting off of acetic acid from acetyl compounds by hydrolysis.

Acetonyl (Radical).—The group $CH_3.CO.CH_2-$

Acetylation.—The introduction of the acetyl group into the molecule of an organic compound, such as alcohols, phenols, amines, etc.; *e.g.* *o*-$HO.C_6H_4.COOH$, salicylic acid, gives acetyl salicylic acid, $CH_3CO.O\,C_6H_4.COOH$ (aspirin). $C_6H_5NH_2$, aniline, gives acetyl aniline, $C_6H_5NHCOCH_3$ (acetanilide). Acetylation is usually carried out with acetyl chloride or acetic anhydride. *See* Esters, Anilides, and Friedel-Craft Reaction.

Acetylides.—Metallic derivatives of acetylene, *e.g.*, sodium acetylide, $CH \equiv C.Na$; copper acetylide, Cu_2C_2.

Acetylisation.—Acetylation (*q.v.*). The term is little used.

Acetyl Number, or **Acetyl Value.**—The number of milligrams of potassium hydrate (KOH) required to neutralise the acetic acid obtained by the saponification (hydrolysis, acetolysis) of one gram of acetylated fat, wax, etc. A useful constant employed in the analysis of fats, oils, and waxes, for indicating the amount of hydroxyl (OH) groups present. *Cf.* Acid Number.

Acetyl (Radical).—The group CH_3CO-, the radical of acetic acid $CH_3.COOH$. The names of acetyl compounds sometimes have the prefix aceto-, *e.g.*, acetoacetic ester, $CH_3COCH_2COOC_2H_5$, and the abbreviation Ac is sometimes employed in formulæ, *e.g.*, methyl acetate CH_3OAc.

Achromic Point.—A term used in connection with the hydrolysis of starch by enzymes to denote the point at which the solution gives no colour with iodine.

Acid Amides.—*See* Amides.

Acid Anhydrides.—*See* Anhydrides.

Acid Azides.—*See* Azides.

Acid Bromides, Acid Chlorides.—*See* Acid Halides.

Acid Halides.—Compounds obtained by replacing the OH of the carboxyl group of organic acids by halogen (chlorine or bromine), *e.g.* benzoyl chloride, C_6H_5COCl, from benzoic acid, C_6H_5COOH; acetyl bromide, CH_3COBr, from acetic acid, CH_3COOH; oxalyl chloride, ClCO.COCl, from oxalic acid, HOOC.COOH, and so on. They all, therefore, contain one or more —COCl(Br) groups. Also termed *acyl* halides.

Acidimetry.—That branch of quantitative analysis which deals with the determination of the amount of acid present in a solution by titration with standard solutions of alkali. *See* Titration, Neutralisation, Analysis, Indicators, and Alkali.

Acidity.—The property or properties in virtue of which a compound is classed as an acid, such as the furnishing of hydrogen ions in solution, action on indicators, neutralisation of alkalis, combination with bases, etc. The amount of acid present in a solution is sometimes spoken of as its acidity (*see* Total Acidity). *See also* Acids.

Acid Number, or **Acid Value.**—The number of milligrams of potassium hydrate (KOH) required to neutralise one gram of fatty acid, or fat, oil, or wax containing free acid. A useful constant employed in the evaluation of fats, waxes, oils, etc. *Cf.* Acetyl Number.

Acidosis.—In biochemistry that condition brought about by excessive withdrawal of bases through the formation of acids within the body These acids are generally acetoacetic and β-hydroxybutyric. This condition shows itself by a depletion of the bicarbonate content of the blood plasma

Acid Radicals.—*See* Radicals, and Acyl (Group).

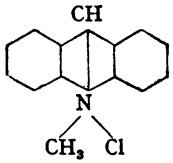
Acid Reaction.—Compounds are said to show an acid reaction when their aqueous solutions change the colour of certain indicators; *e.g.* litmus, blue → red, methyl orange, yellow → pink. *See* Acids and Indicators. *Cf.* Alkaline Reaction.

Acid Salts.—When a polybasic acid is only partially neutralised by a base a compound results which still retains some acid properties, it is termed an *acid salt*; *e.g.* acid potassium sulphate, $KHSO_4$. These salts sometimes have the prefix bi-; *e.g.* sodium bisulphite, $NaHSO_3$. Acid salts are also formed by the combination of normal salt and acid, and may be represented as molecular compounds; *e.g.* acid lead sulphate, $PbSO_4.H_2SO_4.H_2O$. *Cf.* Acids, and Basic Salts.

Acids.—The best definition of the term "acid" is furnished by the ionic hypothesis. According to this hypothesis acids are compounds which undergo electrolytic dissociation in aqueous solution with formation of hydrogen ions Thus all acids contain hydrogen, and they have sometimes been called "salts of hydrogen" The ionogenic (ionisable) hydrogen in acids is replaceable by metals and electropositive (or basic) groups. Acids have certain general characteristics in common: thus they mostly have a sour taste and corrosive action, dissolve metals more or less readily, change the colour of certain indicators, etc.; but they cannot be defined in terms of these properties. Alum, for example, is sour, corrosive, and turns blue litmus red, but contains no hydrogen replaceable by metals. Again, sodium hydrogen sulphate ($NaHSO_4$) is not generally classed as an acid, although it gives hydrogen ions in solution and satisfies the definition given by the ionic hypothesis. It is, in fact, both a salt and an acid, *i.e.* an acid salt. *See* Ionic Hypothesis, Salts, and Basicity.

Aci-nitro- (Group).—*See* Isonitro.

Acridinium (Compounds).—Derivatives of acridine, formed by addition at the nitrogen atom; *e.g.* methyl acridinium chloride is obtained by the action of methyl chloride on acridine. Both the methyl group and the chlorine are directly united to the nitrogen:—



Analogous to ammonium compounds. The corresponding derivatives of acridone are termed acridonium compounds *See* Onium Compounds.

Acridonium (Compounds).—*See* Acridinium (Compounds.)

Acrylyl (Radical).—The group CH_2=CH.CO— The radical of acrylic acid, CH_2:CH.COOH.

Actinism.—Photochemical Activity (*q v.*).

Actinometer.—An apparatus for measuring the photochemical activity or intensity of light.

Actinometry.—The measurement of the photochemical activity or intensity of light. *See* Photochemical Activity.

Activation.—Many substances (elements or compounds) show increased chemical activity (reactivity) after certain treatment, such as heating, exposure to light, electrical discharge, etc. Substances showing this behaviour are said to be activated. The term is widely used in catalysis. The activity of many catalysts varies with the kind of treatment to which they have been subjected. Radiations of various kinds (infra-red, ultra-violet, radium, cathode, X-ray, etc.) are powerful in producing or increasing activation. The term is also applied to substances which promote or increase the activity of catalysts. Such substances are termed activators (catalyst).

Activators (Catalyst).—*See* Activation.

Active Mass.—*See* Mass Action, Law of.

Activity.—*See* Optical Activity.

Actor.—*See* Induced Reactions.

Acyclic.—A term applied to open chain carbon compounds, such as the paraffins and olefines (*q.v.*), in contradistinction to cyclic or ring compounds.

Acylamines.—Amines in which one or two hydrogen atoms are replaced by acyl groups; *e.g.* benzoylaniline (benzanilide), $C_6H_5.CONHC_6H_5$; acetylmethylamine, $CH_3CONHCH_3$. *Cf.* Amides, and Anilides.

Acylamino- (Group).—The group R.CONH—, where R is an alkyl or aryl radical. *See* Acylamines.

Acylation.—The introduction of an acyl group into the molecule of an organic compound; *e g.* benzoyl chloride and ethylamine give benzoylethylamine, $C_6H_5CONHC_2H_5$. (*See* Benzoylation, and Acetylation.) It is usually the amino and hydroxy groups which react with the acid chloride or anhydride. The term is not usually employed when the acyl group is attached to carbon, as in acetoacetic ester. Acyl compounds of this type are generally prepared by other methods. *Cf.*, *e.g.*, Friedel-Craft Reaction, and Hoesch Reaction.

Acyl Bromides, Acyl Chlorides, Acyl Halides.—*See* Acid Halides.

Acyl (Group, Radical).—The group R.CO— where R is an alkyl or aryl radical. It is the acid radical of the acid R.COOH. In the case of a dibasic acid $R.(COOH)_2$ there will be two acyl groups, viz., HOOC R.CO— and —OC.R. CO—. *See* Acetyl, Benzoyl, Oxalyl-, and Radicals.

Acyloins.—Compounds having the general formula

R.CO.CH(OH).R;

e g. acetoin, $CH_3.CO\ CH(OH).CH_3$. *See* Ketols.

Acylous.—A term recently proposed for those atoms or groups which tend to increase the acid character of a molecule; *e.g.* CH_3CO, OH, CO, NO_2, etc. *See* Electropositive. *Cf* Basylous.

Adamkiewicz Reaction.—The production of a violet coloration when concentrated sulphuric acid is added to a solution of protein in glacial acetic acid The coloration is due to the presence of glyoxylic acid, CHO.COOH. in the acetic acid, the former and not the latter acid being the true reagent.

Addition (Additive) Compounds.—Compounds obtained by the direct union of the whole of two or more molecules; *i e.* only one product is formed—*e.g.* acetaldehyde and ammonia to give the aldehyde-ammonia,

$$CH_3\,CHO + NH_3 \rightarrow CH_3CH(OH)\,NH_2,$$

ethylene and bromine to give ethylene dibromide,

$$CH_2 = CH_2 + Br_2 \rightarrow CH_2Br.CH_2Br.$$

Ethylamine and hydrochloric acid unite to give the hydrochloride, $C_2H_5NH_2.HCl$, which further adds on platinum tetrachloride, $PtCl_4$, to give the platinichloride, $(C_2H_5NH_2.HCl)_2$.

$PtCl_4$. *See also* Ammines, Valency, Michael's Reaction, Onium Compounds, and Molecular Compounds.

Addition (Additive) Reaction.—A reaction in which two or more molecules combine to give only one product. *See* Addition Compounds.

Additive Property.—A property of a molecule which is, in general, represented by the sum of the properties of the constituent atoms; *e.g.* molecular weight, which is the sum of the atomic weights; molecular refraction (*q.v.*), heat of combustion (in certain cases), and so on. *See* Colligative Properties.

Adiabatic (Process).—A process carried out in a system in such a way that there is no gain or loss of heat from or to the surroundings, *i.e.* the total heat change of the system is zero. *Cf.* Isothermal Process.

Adsorption.—The taking up of one substance by another by surface condensation. The process takes place according to a definite law, which is expressed by the following equation, termed the *Adsorption Isotherm*:—

$$\frac{x}{m} = k\,p^{\frac{1}{n}} \text{ or } k\,c^{\frac{1}{n}},$$

where x is the amount in grams of the substance adsorbed by m grams of the adsorbent, p is the pressure (if gaseous adsorption), and c the concentration (if adsorption from solution); k and n are constants. The equation represents a reversible equilibrium. The phenomenon is represented by such cases as the taking up of gases by charcoal, of dissolved substances by colloids, and the adsorption layers at the surface of solutions.

Adsorption Isotherm.—*See* Adsorption.

Aelotropy.—*See* Anisotropy.

Affinity (Chemical).—The force which binds the atoms together in their combinations as molecules. In any chemical reaction involving the combination of atoms or groups of atoms the affinity of the combination is measured by the maximum external work (change of free energy) which can be obtained from the process. The affinity is thus measured in terms of energy, and, provided the reaction is carried out isothermally and reversibly, is independent of the course of the reaction, being determined entirely by the initial and final states of the system. In a chemical reaction

$$aA + bB = cC + dD.$$

Where a mols of A and b mols of B react to give c mols of C and d mols of D, the affinity of the reaction is given by

$$A = RT\ln K + RT\ln\frac{[A]^a \times [B]^b}{[C]^c \times [D]},$$

where A is the affinity, R the gas constant, T the absolute temperature at which the reaction is carried out, K the equilibrium constant, and [A], [B], [C], and [D] the concentrations of A, B, C, and D respectively. If the reaction is a gaseous one these represent partial pressures. *See* Free Energy.

Affinity Constant.—*See* Electrolytic Dissociation.

Agglomerating Agent.—A substance which brings about the aggregation of the particles of a colloid.

Agglutinins.—Anti-bodies (*q.v.*) which cause the agglutination of bacteria.

Agglutination, Agglutinisation.—The formation of aggregates of bacteria previously distributed uniformly in a fluid. The term is usually restricted to aggregation produced by anti-bacterial serum. It is explained as due to the union of certain molecules in the bacteria, known as agglutinogens, with corresponding (hypothetical) substances, the agglutinins, in the serum.

Agglutinogens.—*See* Agglutination.

Albuminates.—Compounds of the albumins with metals; *e.g.* copper albuminate is precipitated when a solution of copper sulphate is added to a solution of albumin. The albuminates are considered by some authorities to be, not salts of the albumins, but coagulated colloidal albumin containing adsorbed metal ions.

Albuminoids.—A class of proteins which form the connective tissues of the animal body; *e.g.* gelatin, collagen, keratin (from hair), etc. These bodies are also known as scleroproteins *See* Proteins.

Albumins.—A group of proteins which are coagulated by boiling their solutions in presence of a little acetic acid. They are soluble in water, are not precipitated by saturation with sodium chloride or half-saturation with ammonium sulphate, but are precipitated by complete saturation with the latter reagent. *See* Proteins.

Albumoses.—*See* Proteoses.

Alcogels.—*See* Gels.

Alcoholates.—Compounds analogous to the hydrates (hydroxides), in which the group methoxy, OCH_3, ethoxy, OC_2H_5, etc., takes the place of hydroxyl, OH; *e.g.* sodium alcoholate, $NaOC_2H_5$; calcium alcoholate, $Ca(OC_2H_5)_2$; chloral alcoholate, $CCl_3CH(OH).OC_2H_5$; etc. *See* Methoxides and Ethoxides. The term is

also sometimes applied to compounds containing alcohol of crystallisation; *e g.* $CaCl_2 4CH_3OH$.

Alcoholometer.—A hydrometer for estimating the amount of (ethyl) alcohol present in alcohol-water mixtures. The estimation of alcohol by this method is termed alcoholometry

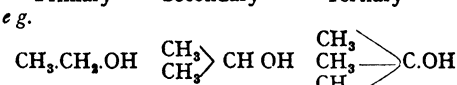
Alcoholometry.—*See* Alcoholometer.

Alcohols.—In general, alcohols are compounds containing a hydroxyl group directly attached to carbon, but the term is restricted to those compounds in which the OH group shows certain characteristics, but the division is not a sharp one. The carboxylic acids, for example, contain OH linked to carbon, but are in no sense alcohols; and the phenols, in which the OH is attached to a nuclear aromatic carbon, although possessing some of the properties of alcohols, are not usually classed as such. The alcoholic hydroxyl has many properties in common with the hydroxyl of the inorganic bases (hydroxides).

Alcohols containing one OH group are termed *monohydric*, and are divided into three classes, viz. *primary*, *secondary*, and *tertiary*, according to whether the OH is attached to a primary ($-CH_2$), secondary ($>CH$), or tertiary ($\gg C$) carbon atom Thus:

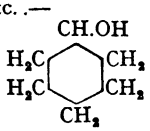
$R.CH_2OH$	$R_1R_2.CHOH$	$R_1R_2R_3.C.OH$
Primary	Secondary	Tertiary

e g.



Ethyl alcohol	Isopropyl alcohol	Tertiary Butyl alcohol.

The secondary alcoholic OH may be attached to a cyclic carbon as in menthol, borneol, cyclohexanol, etc.:—



The radicals R_1, R_2, R_3 may contain other characteristic groups; *e g.* double or triple bonds, giving unsaturated alcohols, such as allyl alcohol, $CH_2=CH.CH_2OH$; keto groups, giving keto-alcohols (ketols, *q.v.*); carboxyl groups, giving alcohol acids (hydroxy-acids, *q v.*); and so on.

If two alcoholic hydroxyls are present, the alcohol is termed *dihydric*; *e g* α-propylene glycol, $CH_3 CH(OH).CH_2 OH$ (*see* Glycols). If there are three OH groups, the alcohol is *trihydric*; *e.g.* glycerol, $CH_2OH.CHOH.CH_2OH$. Alcohols containing several OH groups are classed as *polyhydric*. *See* Sugars, and Aldehydrols.

Alcoholysis.—The treatment of an ester $R.COOR_1$ with an alcohol $R_2 OH$, resulting in the formation of the ester $R.COOR_2$ and the alcohol $R_1.OH$. The process is analogous to hydrolysis (*q v.*), the alcohol $R_2 OH$ taking the place of water H.OH or hydroxide, M.OH. *Cf.* Esterification.

Alcosols.—*See* Sols.

Aldazines.—Compounds of the type

$$R\,CH{=}N.N{=}CH.R,$$

formed by the condensation of two molecules of aldehyde, R CHO, with one molecule of hydrazine, $H_2N\,NH_2$; *e g.* benzaldazine, $C_6H_5.CH : N.N : CH.C_6H_5$ from benzaldehyde. *Cf.* Ketazines.

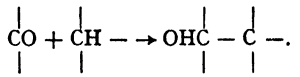
Aldehydes.—Compounds of the type R.CHO, R being an organic radical, and —CHO the characteristic aldehyde group; *e g.* $CH_3.CHO$, acetaldehyde; $C_6H_5.CHO$, benzaldehyde, etc. In formaldehyde, H.CHO, R is hydrogen. In dialdehydes there are two CHO groups, *e g.* glyoxal, OHC CHO; succindialdehyde, $OHC.CH_2 CH_2 CHO$, etc.

Aldehydrols.—Compounds of the type $R.CH(OH)_2$. Only very few are known; *e.g.* chloral hydrate, $CCl_3 CH(OH)_2$.

Aldimines.—Compounds of the type R.CH = NH. They are derived from aldehydes by replacing the O by NH. *See* Imines, and Schiff's Bases.

Aldo-.—A prefix frequently employed in the designation of sugars to denote that the compound is an aldehyde (aldose); *e.g.* aldopentose, $CH_2OH(CHOH)_3.CHO$. *See* Sugars.

Aldol Condensation.—A reaction of the type



It is generally, though not necessarily, restricted to condensations between aldehydes, ketones, and aldehydes and ketones; *e.g.*

1. *See* Aldolisation.
2. $CH_3.CO.CH_3 + OC.(CH_3)_2 \rightarrow$
   Acetone
   $CH_3COCH_2C(OH)(CH_3)_2$
   Diacetone alcohol
3. $CH_3CHO + CH_3.CO.CH_3 \rightarrow$
   Aldehyde Acetone
   $CH_3CH(OH)CH_2COCH_3$
   Acetone-isopropyl alcohol

Aldolisation.—The condensation of two molecules of an aldehyde to give the corresponding aldol; *e.g.*

$CH_3.CHO + CH_3.CHO \rightarrow CH_3CH(OH).CH_2.CHO$
aldehyde aldol

Aldols.—*See* Aldolisation.

Aldoses.—A generic term for those members of the carbohydrates (sugars) which are aldehydes, such as xylose, glucose, etc. *See* Sugars.

Aldosides.—*See* Glucosides.

Aldoximes.—*See* Oximes.

Alicyclic (Compounds).—The term alicyclic is compounded of aliphatic and cyclic, and denotes cyclic or ring compounds derived from the corresponding acyclic (aliphatic or open chain) compounds; *e.g.* the cyclo-paraffins (naphthenes) (*q.v.*). They are so termed because of the similarity of their properties to those of the corresponding acyclic compounds, and to distinguish them from the aromatic compounds, the transition to which involves a very striking and abrupt change of properties. *See* Aromatic Compounds.

Aliphatic.—A general term applied to the acyclic hydrocarbons and their derivatives. The name is derived from those compounds of the normal paraffins present in fatty substances, such as palmitic and oleic acids, cetyl alcohol, etc. One of the two main divisions into which the hydrocarbons are divided, the other being aromatic (*q.v.*). *See* Acyclic, Paraffins, Olefines, and Fatty Acids.

Alkali Metals.—The metals potassium, sodium, lithium, rubidium, and caesium.

Alkalimetry.—That branch of quantitative analysis in which the amount of alkali present in a solution is determined by titration (neutralisation) with standard acid. *See* Titration, Neutralisation, and Analysis.

Alkaline Earth Metals.—The metals calcium, strontium, and barium.

Alkaline Earths.—Naturally occurring compounds (minerals) of the metals calcium, strontium, and barium; *e.g.*

Aragonite, Calcite, Marble	$CaCO_3$
Gypsum	$CaSO_4$
Fluorspar	CaF_2
Strontianite	$SrCO_3$
Celestine	$SrSO_4$
Witherite	$BaCO_3$

Alkaline Reaction.—Compounds are said to show an alkaline reaction when they change the colour of certain indicators; *e.g.* litmus, red → blue, methyl orange, pink → yellow.

Alkalinity.—The property or properties in virtue of which a compound is classed as an alkali, such as the furnishing of hydroxyl ions in solution, action on indicators, neutralisation of acids, etc. The term is also employed to denote the amount of alkali present in a solution. *Cf.* Acidity.

Alkali Reserve.—A term applied to blood to denote the proportion of alkali (bicarbonate) present in the blood and available for neutralisation of any acid which may appear therein.

Alkalis.—A name originally given to the carbonates of potassium and sodium, and later ammonium carbonate. It is now used to designate principally the hydroxides and carbonates of potassium and sodium, and to a lesser extent those of the other alkali metals and alkaline earth metals In a generally accepted usage, the name is applied to all the more or less strongly basic compounds of the above metals and ammonia.

Alkali Salts.—Generally, the salts (chlorides, carbonates, sulphates, etc.) of potassium and sodium, but sometimes including those of the other alkali and alkaline earth metals.

Alkali Tolerance.—The amount of alkali (bicarbonate) required to make urine alkaline to litmus.

Alkaloids.—A large class of naturally occurring organic compounds, the chief common characteristic of which is a more or less powerful physiological action Most of these compounds are found in plants, and are known as vegetable alkaloids, and a few in animals, the so-called animal alkaloids They all contain carbon hydrogen, and nitrogen, and many contain oxygen in addition. They are basic substances of more or less complex constitution. They may be roughly classified as derivatives of pyridine, quinoline, isoquinoline, purine, and other parent nuclei, but most of those of known constitution are derived from these compounds *See* Bases, Purine Bases, Xanthine Bases, and Ptomaines.

Alkamines.—Compounds which function as both alcohols and amines (amino-alcohols, or alcohol-amines); *e.g.* $CH_3.CH(OH).CH_2.NH_2$ aminoisopropyl alcohol. *See* Alcohols, and Amines.

Alkanes.—The saturated acyclic hydrocarbons

Alkenes.—The olefines (*q.v.*).

Alkines.—The acetylenic hydrocarbons.

Alkoxy, Alkoxyl (Radical).—The group —O.R where R is an alkyl radical; *e.g.* methoxy

Alkylamines.—*See* Amines.

Alkylammonium (Radical).—The ammonium radical, NH_4—, in which one or more of the hydrogen atoms are replaced by alkyl groups; *e.g.* ethylammonium (bromide), $C_2H_5NH_3$—Br; trimethylammonium (iodide), $(CH_3)_3NH$ — I. *See* Onium Compounds.

Alkylation.—The process of introducing one or more alkyl groups into the molecule of a compound (usually organic); *e.g.* the conversion of aniline, $C_6H_5.NH_2$, to mono- or dimethylaniline, $C_6H_5NH.CH_3$ or $C_6H_5N(CH_3)_2$; and phenol, $C_6H_5.OH$, to methoxybenzene (anisole), $C_6H_5.OCH_3$. The introduction of the methyl group is termed *methylation*; that of the ethyl group *ethylation*. *Cf.* Acylation.

Alkylene (Radicals).—Aliphatic radicals containing one or more double (ethenoid) bonds; *i.e.* olefine radicals, *e g* allyl, *q.v.* *See* Olefines.

Alkyl (Groups, Radicals).—Aliphatic univalent hydrocarbon radicals; *e g.* methyl, CH_3—; ethyl, C_2H_5—; isopropyl, $(CH_3)_2CH$ —; tertiary butyl, $(CH_3)_3C$—, etc.

Alkylogens.—Alkyl esters of the halogen acids; *e g.* methyl iodide, ethyl bromide, etc.

Alkyls.—Compounds of metals with alkyl radicals; *e g* zinc ethyl, $Zn(C_2H_5)_2$. Sometimes termed hydrocarbo bases. *See* Organometallic Compounds.

Allelotropism, Allelotropy.—The formation of an equilibrium mixture of the two dynamic isomers of a compound; *e g.* the keto- and enol- forms of formylphenylacetic ester:

$$H\,CO.CH(C_6H_5)COOC_2H_5 \rightleftharpoons H\,C(OH).C(C_6H_5)COOC_2H_5.$$

Such an equilibrium mixture is termed an *allelotropic mixture* Like other equilibria, allelotropism depends on the temperature and nature of the solvent. *See* Isomerism, Dynamic.

Allihn's Method.—A gravimetric method of estimating carbohydrates by reduction of Fehling's solution (*q.v.*).

Alloisomerism.—Geometrical isomerism of the fumaric-maleic type The prefix allo- is employed to designate the more stable to heat of the two alloisomers. Thus fumaric acid may be termed allo-maleic acid. *See* Isomerism, Geometrical.

Alloisomers.—*See* Alloisomerism.

Allologic Series.—A series of hydrocarbons in which there is a constant difference between any two members; *e.g.* the paraffins, CH_4, C_2H_6, C_3H_8, etc. (difference, CH_2); C_6H_6, $C_{10}H_8$, $C_{14}H_{10}$, etc. (the benzene, naphthalene, anthracene series; difference, C_4H_2). the so-called benzologic series. Similarly, C_6H_6, $C_{12}H_{10}$, $C_{18}H_{14}$ (diphenyl series), termed the phenylogic series; and $C_{10}H_8$, $C_{16}H_{10}$, $C_{22}H_{12}$ (pyrene series), the so-called perilogic series; and so on. These terms are only very recently introduced, and have not, as yet, come into general use.

Allotrope.—*See* Allotropism.

Allotropism, Allotropy.—When an element can exist in the solid state in more than one form it is said to exhibit allotropy. The different forms are called allotropic modifications, or allotropes, and possess different properties. The term is sometimes applied to liquid forms. If there is a definite temperature above or below which only one of the two forms is stable (*i.e.* the one passes completely into the other), the allotropy is said to be *enantiotropic* (*enantiotropy*). If there is a definite amount of each present at any given temperature (*i e.* an equilibrium) it is termed *dynamic allotropy*. If one form is more stable at all temperatures than the other, the allotropy is termed *monotropic* (*monotropy*). The elements carbon (diamond, graphite, charcoal), phosphorus (red, yellow), sulphur (rhombic, monoclinic, colloidal) are common examples. *Cf.* Isomerism. *See* Polymorphous.

Alloy.—A combination of two or more metals obtained by fusing them together. On cooling the liquid product a solid is obtained which may be an intimate mechanical mixture, an intermetallic compound, a solid solution or a homogeneous mixture (mixed crystals), or a combination of these. Alloys show definite properties for definite compositions.

Allyl (Radical).—The group $CH_2{=}CH.CH_2$—.

Alpha Particles (α-Particles).—*See* Radioactivity.

Alpha Position (α-position).—*See* Table of Symbols, p. 157.

Alpha Rays (α-Rays).—*See* Radioactivity.

Alphyl (Radical).—A term sometimes used to denote a mixed aliphatic-aromatic radical (or compound); *e.g.* benzyl, $C_6H_5.CH_2$—; cinnamyl, $C_6H_5.CH : CH.CH_2$—, etc.

Alternate Polarity.—*See* Polarity (Atoms).

Aluminothermic.—*See* Thermite (Process).

Alums.—A class of compounds having the general formula

$$M'_2SO_4.M'''_2(SO_4)_3.24H_2O, \text{ or}$$
$$M'M'''(SO_4)_2.12H_2O.$$

M' is a univalent metal such as potassium, sodium, caesium, silver, etc. Ammonium, NH_4, may also take the place of M', forming the ammonium alums. M''' is a tervalent metal,

such as aluminium, iron, chromium, etc. Selenates, as well as sulphates, form alums (selenium alums). All the alums are isomorphous, crystallising in the octahedral system. The following are typical alums:—Common alum, alum, or potash alum, K_2SO_4, $Al_2(SO_4)_3$. $24H_2O$; iron alum, $K_2SO_4.Fe_2(SO_4)_3.24H_2O$; chrome alum, $K_2SO_4.Cr_2(SO_4)_3\ 24H_2O$; ammonium alum, $(NH_4)_2SO_4.Al_2(SO_4)_3.24H_2O$. *See* Pseudo-alums.

Am.—An abbreviation for ammonium, NH_4; sometimes used in formulæ

Amalgamation.—*See* Amalgams

Amalgams.—A number of metals dissolve in mercury, the products obtained being termed amalgams. In many cases definite compounds of the metal with mercury are formed as, *e.g.*, in the case of potassium and sodium. The process of forming these metal-mercury products is termed amalgamation, and is used industrially *Cf.* Alloys.

Amicrons.—In Zsigmondy's arbitrary classification amicrons are particles having a diameter less than 5×10^{-7} cms. They are thus below the limit of ultramicroscopic vision, but greater than the free molecules in true solution. *Cf.* Microns and Sub-microns.

Amidation.—The introduction of one or more amino groups into the molecule of an organic compound.

Amides.—Compounds obtained by replacing one hydrogen atom in ammonia by an acid radical, or, alternatively, by replacing the OH of the carboxyl group by NH_2; *e.g.* acetic acid, $CH_3.COOH \rightarrow$ acetamide, CH_3CONH_2. If one or both of the amido hydrogen atoms are replaced by radicals, substituted amides are obtained; *e.g.* methyl acetamide, $CH_3CONHCH_3$. The term is also applied to metallic derivatives of ammonia; *e.g.* sodamide (sodium amide), $NaNH_2$; but the former class of compounds is distinguished as *acid* amides. *See* Acylamines, Anilides, and Imides.

Amidines.—Compounds of the type

$$R\,C(=NH)\,/NH_2$$

e.g. Acetamidine, $CH_3C(:NH).NH_2$. *Cf.* Amidoximes.

Amidogen.—The radical $-NH_2$.

Amidoximes.—Compounds of the type

$$R.C(=N.OH)\,/NH_2$$

e.g. ethenyl amidoxime, $CH_3.C(NH_2):N.OH$. *Cf.* Amidines.

Amidoxy, Amidoxyl (Group).—The group $-O-NH_2$, as, *e.g.*, in amidoxyl acetic acid, $NH_2.O.CH_2COOH$.

Aminates.—Compounds of tertiary amines with organometallic compounds (*q.v.*); *e.g.* $(C_2H_5)_3N\ BrMgCH_3$. *See* Grignard Reagents, and Etherates

Amines.—Compounds derived from ammonia by replacing one, two, or all three of the hydrogen atoms by alkyl, aryl, or alphyl radicals. This gives rise to three classes of amines, viz (1) *Primary*, $R.NH_2$ (*e.g.* methylamine, $CH_3.NH_2$; aniline, $C_6H_5.NH_2$; benzylamine, $C_6H_5\,CH_2\,NH_2$). (2) *Secondary*, R_1R_2NH (*e.g.* dimethylamine, $(CH_3)_2\,NH$; diphenylamine, $(C_6H_5)_2.NH$; ethylbenzylamine, $C_2H_5.NH.CH_2C_6H_5$). (3) *Tertiary*, $R_1R_2R_3N$ (*e.g.* trimethylamine, $(CH_3)_3.N$; triphenylamine, $(C_6H_5)_3\,N$).

Amines containing all alkyl radicals are termed *alkylamines*; those with aryl radicals, *arylamines*, and those with both, *mixed amines*. *Cf.* Amides, and Anilides.

Aminic.—A term of reference to the amino group or its properties Also *aminoid*.

Aminity.—The ability of amines to enter into addition reactions, such as, *e.g.*, the formation of salts with acids. *See* Addition Compounds, and Alkylammonium.

Amino-.—A prefix denoting the presence of an amino group, NH_2, NH, or N, as in the amines. *See* Amines. *Cf.* following.

Amino-acids.—Compounds containing both amino- and carboxyl- groups in the molecule; *e.g.* aminoacetic acid, $CH_2(NH_2).COOH$. The term is more often reserved for those acids derived from proteins by hydrolysis. *See* Polypeptides.

Aminoazo- (Compounds).—Compounds containing the grouping $R.N{:}N.R\,NH_2$. They are formed by isomerisation of the diazoamino-compounds, the process sometimes being termed aminolysis; *e.g.*

$$C_6H_5N{:}N.NHC_6H_5 \rightarrow C_6H_5N{:}N.C_6H_4.NH_2.$$

Diazoaminobenzene. Aminoazobenzene.

More usually they are formed by direct coupling of a diazonium salt with an amine.

Aminoid.—*See* Aminic.

Aminolysis.—*See* Aminoazo- (Compounds).

Ammines.—Complex compounds of metallic salts with ammonia. Many metals have the property of forming these ammines or ammino-compounds, such as platinum (*e.g.* tetrammine-platinous chloride, $[Pt(NH_3)_4]Cl$), and cobalt (*e.g.* hexammine-cobaltic chloride, $[Co(NH_3)_6]Cl_3$. A large number of such complex compounds

have been prepared. The platinum compounds are termed *platinammines*, those of cobalt *cobaltammines*, and so on. The system of nomenclature and the formulæ are due to Werner. The ammines are also known as *ammoniates*.

Ammino- (Compounds).—*See* Ammines.

Ammoniates.—*See* Ammines.

Ammono-Acids.—*See* Ammono-Compounds

Ammono-Bases.—*See* Ammono-Compounds.

Ammonobasic Salts.—*See* Ammono-Compounds.

Ammono-Compounds.—Compounds in which the NH_2 group replaces OH. The latter are termed *aquo-compounds* for distinction; *e.g.* $C_6H_5CONH_2$ (benzamide) is an ammono-acid, the aquo-acid being $C_6H_5CO\,OH$ (benzoic acid). $NaNH_2$ (sodamide) is an ammono-base, NaOH being the corresponding aquo-base, and so on. Ammonobasic salts are basic salts containing NH_2 in place of OH; *e.g.* potassium ammonoaluminate, $(NH_2)_2AlNHK$, corresponding to the aquo-basic salt $(HO)_2AlOK$; and mercury ammono-chloride, $Cl\,Hg.NH_2$, corresponding to Cl.Hg OH, etc. Mercury forms a series of such compounds, termed *mercuriammonium* compounds The formation of these compounds (in liquid ammonia) is sometimes called *ammonolysis*.

Ammonolysis.—*See* Ammono-Compounds.

Amorphous.—The word means "without form," and as applied to elements and compounds generally signifies "non-crystalline." Most homogeneous liquids have the property of crystallising on sufficient cooling. A solidified liquid which is not crystalline may be regarded as a super-cooled liquid, since it exhibits the characteristic property of the liquid in being completely isotropic It has no special internal or external structure as have crystals Glass and other silicates, plastic sulphur, and many colloidal substances such as rubber and rosin are examples.

Amphi-.—*See* Oximes.

Ampholyte.—An abbreviation for amphoteric electrolyte. *See* following.

Amphoteric Compounds.—Compounds which can function both as an acid and as a base; *e.g.* aluminium hydroxide, $Al(OH)_3$, which acts as a base by forming salts with acids (HCl gives $AlCl_3$), and as an acid by forming salts with bases (NaOH gives $Al(ONa)_3$). If the compound yields both hydrogen and hydroxyl ions in solution it is termed an *amphoteric electrolyte*; *e.g.* aminobenzoic acid. When both of these ions are produced, the remaining neutral ion is termed an *amphoteric ion*. In the case of aminobenzoic acid this ion is $C_6H_4(NH_3^+)COO^-$. The phenomenon is called *amphoteric ionisation*.

Amphoteric Electrolytes.—*See* Amphoteric Compounds.

Amphoteric Ionisation.—*See* Amphoteric Compounds.

Amphoteric Ions.—*See* Amphoteric Compounds.

Amylolysis.—The hydrolysis of starches. *See* Enzymes.

Amyl (Radical).—The group $CH.CH_2.CH_2.CH_2.CH_2$—.

Anabolism.—*See* Metabolism.

Anærobiosis.—The maintenance of life by certain organisms in absence of oxygen.

Anæsthetics.—Substances which produce unconsciousness; *e g.* chloroform, ether, alcohol, etc. In a physiological sense they act essentially by rendering certain cells temporarily incapable of responding to stimuli.

Analgesics.—Drugs which diminish pain.

Analyser.—*See* Polarimeter

Analysis (Chemical).—Under this term is included all methods for the detection and (or) estimation of the constituents of a compound or mixture. There are several branches of chemical analysis. These are:

(1) *Electroanalysis* (*Electrochemical Analysis*).—The separation of the constituents of a mixture or compound by means of an electric current; *e.g.* the separation (deposition) of metallic copper from a solution of copper and nickel sulphates (*see* Magnus' Rule). The term is also applied to electrical methods (E.M.F. and conductivity) for following the course of a reaction. *See* Electrometric Titration.

(2) *Elementary Analysis.*—The estimation of the elements in a compound. The term is generally confined to organic analyses. Also termed ultimate analysis.

(3) *Organic Analysis.*—This term is retained to distinguish the qualitative and quantitative analysis of organic compounds. This involves the determination of carbon, hydrogen, nitrogen, sulphur, and the halogens. *See* Combustion (Analysis).

(4) *Proximate Analysis.*—Methods applied to examination of a substance for the purpose of detecting and estimating the presence of certain constituents, such as moisture, ash, extractives (*i.e.* substances which may be removed by treatment with solvents, such as waxes, resins, albuminoids,

etc.), free acids and bases, hydroxy, methoxy, etc., groups, unsaturation, and so on. This type of analysis is usually employed in the evaluation of commercial products for which a complete (ultimate) analysis is not required, and which would, in many cases, be a difficult and lengthy undertaking, as, *e g.*, in the case of oils, fats, waxes, gums, resins, etc.

(5) *Qualitative Analysis.*—The detection of the constituents of a compound or mixture without reference to the amount of these present.

(6) *Quantitative Analysis.*—The determination of the amounts of the constituents present in a mixture or compound. There are two main divisions, viz.:

(*a*) *Gravimetric Analysis.*—One or more of the constituents are completely isolated and weighed; and

(*b*) *Volumetric Analysis.*—The amount of the constituent is measured in solution by titration with a standard solution of a reagent with which it reacts. *See* Standard Solution and Titration.

(7) *Spectrum Analysis.*—The detection of elements or compounds by means of their characteristic emission or absorption spectra. *See under* Spectrum.

(8) *Ultimate Analysis.*—Complete elementary analysis, as distinguished from proximate analysis.

See also Positive Ray Analysis, X-ray Analysis, and Capillary Analysis.

Anchoring Groups.—A term used by Erlich in connection with his theory of the action of drugs, to denote that group (OH, OCH_3, etc.) in the molecule of the drug which enables the drug to attach itself to the cells and so enable the pharmacophore group (*q v.*) to exert its full physiological effect.

Ångstrom Unit.—A ten-millionth of a millimetre, or 0·1μμ. A commonly employed unit for measuring the wave-lengths of light. *See* Table of Symbols, p. 157.

Anhydrides.—In general, compounds obtained by reactions involving the elimination of one or more molecules of water from one or more molecules of the reacting compounds. The term is generally restricted to the acid anhydrides; *e.g.* acetic anyhdride from acetic acid:

$$2CH_3.COOH \rightarrow CH_3CO.O.COCH_3 + H_2O;$$

phthalic anhydride from phthalic acid:

$$C_6H_4(COOH)_2 \rightarrow C_6H_4(CO)_2O + H_2O;$$

and phosphoric anhydride from phosphoric acid:

$$2H_3PO_4 \rightarrow P_2O_5 + 3H_2O.$$

Mixed anhydrides are obtained by the elimination of water from one molecule each of two different acids; *e.g.* acetopropionic anhydride from acetic and propionic acids,

$$CH_3.COOH + C_2H_5.COOH \rightarrow CH_3CO.O.CO.C_2H_5 + H_2O.$$

Names other than anhydride are usually employed for compounds thus derived from groups other than acidic. *See* Ethers, Lactones, Oxides; *Cf.* Dehydration, and Condensation.

Anhydro-.—A prefix sometimes employed for convenience in naming a compound produced by a reaction involving elimination of water *See* Hemicelluloses, and Anhydrobases.

Anhydrobases.—Compounds formed by elimination of a molecule of water in reactions of the type:

$$C_6H_4\langle^{OH}_{NH_2} + R.COOH \rightarrow C_6H_4\langle^{O}_{N}\rangle\!\!/C.R$$

Benzoxazole

Similarly with Benziminazoles and Benzthiazoles, etc. All the anhydrobases are not basic. The term is merely one of convenience in naming this class of compound.

Anhydrous.—When a compound is deprived of all hygroscopic water (moisture) and water of constitution (crystallisation), it is said to be anhydrous. The word is not altogether synonymous with "dry"; *e g* crystalline copper sulphate, $CuSO_4\,5H_2O$, may be quite dry, but only the pure compound $CuSO_4$ is anhydrous

Anilides.—Derivatives of aniline formed by replacement of the hydrogen of the NH_2 by acid radicals; *e g* acetanilide, $C_6H_5NHCOCH_3$, and benzanilide, $C_6H_5CONHC_6H_5$.

Anilino- (Radical).—The group $C_6H_5.NH—$.

Anils.—Phenyl imides, *i.e.* those containing the group $C_6H_5N<$, formed from aniline and a dibasic acid. Thus succinic acid (anhydride) and aniline give succinanil.

$$\begin{matrix} CH_2 - CO \\ | \\ CH_2 - CO \end{matrix}\!\!\rangle N.C_6H_5.$$

Anion.—The positive ion furnished by an electrolyte. Typical anions are Cl′ (from HCl), OH′ (from bases), SO_4'' (from H_2SO_4), R.COO′ (from carboxylic acids), BO_3''' (from H_3BO_3) $Fe(CN)_6''''$, etc. *See* Ions, and Electrolysis.

Anisal (Radical).—The group

$$p\text{-}CH_3O.C_6H_4.CH=.$$

Anisotropic Liquids.—*See* Liquid Crystals.

Anisotropy.—Bodies exhibiting different physical properties in different directions are said to be anisotropic. The property is termed

anisotropy. Crystals, for example, are in general, anisotropic. *Cf.* Isotropy, Liquid Crystals.

Anisoyl (Radical).—The group

$$p\text{-}CH_3O.C_6H_4.CO-.$$

The radical of anisic acid.

Anisyl (Radical).—The group $CH_3O.C_6H_4-$.

Annular Systems.—Cyclic (or Ring) Compounds (*q.v.*).

Anode.—In electrolysis, the positive pole or plate. *See* Electrolysis.

Anodic Oxidation.—Many oxidation processes can be carried out at the anode during electrolysis. Thus chromium sulphate gives chromic acid, potassium hydrogen sulphate is oxidised to the persulphate, etc. Many of these oxidations are due to secondary reactions in which oxygen is produced; *e.g.* the SO_4'' ion when liberated at the anode reacts with water, giving H_2SO_4, and oxygen, which is thus free to react with any oxidisable substance present. *See* Electrolysis. *Cf.* Cathodic Reduction.

Anodophoresis.—The migration of suspended particles towards the anode under the influence of a unidirectional current. *See* Cataphoresis. *Cf.* Cathodophoresis, Electrophoresis, and Electro-endosmosis

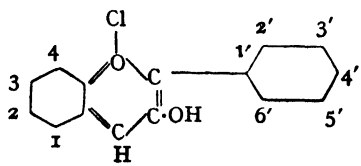
Anolyte.—In electrolysis, if the solution be divided by a diaphragm, that portion containing the anode is termed the anolyte. The other portion of the electrolyte containing the cathode is termed the *catholyte*.

Anomalous Ionisation.—After applying the viscosity correction to molecular conductivity values, it is found in many cases, particularly with concentrated solutions, that the exact inverse proportionality between viscosity and conductivity does not hold In these cases the dissociation (ionisation) is said to be anomalous.

Anomalous Rotatory Dispersion.—*See* Rotatory Dispersion.

Anorthic (Crystals). *See* Triclinic.

Anthocyanidins.—The sugar-free part of the anthocyanins. They are closely related to the flavonols and are derived from the structure :



by substitution of hydroxyl or methoxyl at 1, 3, 3', 4', 5'.

Anthocyanins.—The glucosidic form of the anthocyans, containing the anthocyanidins combined with various sugars such as glucose, galactose, etc.

Anthocyans.—The pigments which produce the deep colourings of flowers and other parts of plants, viz. the reds, violets, and blues as distinct from the yellows due to flavones and flavonols and the greens of chlorophyll. The anthocyans include the anthocyanins and anthocyanidins (*q.v.*).

Anthoxanthins.—A name suggested by Willstätter for the yellow plant pigments usually known as flavones and xanthones.

Anti-.—*See* Oximes.

Antibodies.—When foreign substances, such as proteins, are injected into the blood, bodies are produced by the blood which tend to counteract the effect of the injected substance (protein, etc). These bodies are known generally as anti-bodies. *See* Anti-enzymes, Antitoxins, and Anti-gens.

Anticatalysts.—Substances which inhibit the activity of catalysts ; *e.g.* in the contact process for SO_3 a trace of arsenic will render the catalyst (platinum) inactive, so that the $SO_2 \rightarrow SO_3$ oxidation no longer takes place. The catalyst in such cases is said to be "poisoned." Anticatalysts are also termed catalyst poisons. *Cf* Activators, and Negative Catalysis.

Anticathode.—The platinum or tungsten plate in an X-ray tube, used to focus the rays from the cathode.

Anti-enzymes.—Bodies produced by the blood which counteract the action of enzymes.

Anti-gens.—The injected substances which cause the production of antibodies (*q.v.*).

Antimonyl (Radical).—The radical SbO— ; *e.g.* antimonyl chloride, SbOCl, and nitrate, $SbO(NO_3)$.

Antioxidants (Antioxygens). — Substances which, when added in small quantity to easily oxidisable substances in solution (*e.g.* sodium sulphite) prevent the rapid oxidation by atmospheric oxygen. *Cf.* Catalysis, and Negative Catalysis.

Antipodes (Optical).—*See* Enantiomorphs.

Antipyretics.—Substances which have the effect of lowering the body temperature ; *e.g.* antipyrine.

Antiseptics.—Substances used to prevent the development of bacteria, either by destroying them or by inhibiting their growth ; *e.g.* phenol, the cresols, etc.

Antitoxins.—Substances produced from the

blood plasma which counteract the action of toxins. *See* Toxins.

Aq.—An abbreviation for water, H_2O. It is sometimes used in formulæ to denote water of crystallisation; *e.g.* $CuSO_4 5Aq$. In physical chemistry it sometimes has the meaning "a large volume of water." Thus NaCl.Aq. means "a very dilute solution of salt"

Aquo- (Compounds).—*See* Ammono-Compounds.

Arc Spectrum.—*See* Spectrum.

Ardometer.—An instrument for measuring high temperatures, such as those of furnaces The measurement is made by comparing the intensity of the light radiation with an adjustable image, the temperature for producing which is measured electrically. A type of radiation pyrometer. *See* Pyrometers

Aræometer.—A type of hydrometer in which the readings are read off from a scale above the liquid. There is an index inside the float which extends to the scale

Areopycnometer.—A special kind of pycnometer for measuring the specific gravity of pasty or viscous substances.

Argentometry.—That branch of quantitative analysis dealing with estimations involving the use of standard solutions of silver salts, *e.g.* the estimation of chlorine (chlorides) with silver nitrate. *Cf.* Iodometry.

Arnold-Lipliawsky Reaction.—The detection of acetoacetic acid in urine, which depends upon the formation of a brick-red coloration when diazotised *p*-aminoacetophenone is added to urine in the presence of ammonia

Aromatic (Compounds).—The benzene, naphthalene, anthracene, phenanthrene, etc, hydrocarbons and their derivatives, in which the aromatic nucleus (*i.e.* the benzene ring) is present as such. *Cf* Aliphatic, and Hydroaromatic (Compounds)

Arseno- (Group).—The group $-As=As-$, as, *e.g.*, in arsenobenzene, $C_6H_5As=AsC_6H_5$ *See* Diazo Reaction.

Arsines.—Derivatives of arsine, AsH_3; *e.g.* trimethylarsine, $As(CH_3)_3$. *See* Arsonium Compounds. *Cf.* Stibines, and Phosphines.

Arsonation.—The introduction of the arsono radical (*q.v.*) into the molecule of an organic compound; *e.g.* phenol *p*-arsonic acid, $HO.C_6H_4.AsO_3H_2$, from phenol and arsenic acid. Analogous to sulphonation (*q.v.*).

Arsonium Compounds.—Compounds of the type $R_1R_2R_3As\,RX$, where R_1, etc., are organic radicals and X a negative atom or group, *e.g.* trimethylphenylarsonium bromide, $(C_6H_5)(CH_3)_3As.Br$. *See* Onium Compounds.

Arsono (Radical).—The group $AsO.(OH)_2$—, derived from arsenic acid, $AsO.(OH)_3$.

Aryl.—A term applied to radicals derived from aromatic compounds, which are themselves sometimes called aryl compounds. Thus, *e.g.* phenyl, phenylene, tolyl, naphthyl, and so on. *Cf.* Alkyl, Alphyl.

Arylamines.—*See* Amines.

Assay.—A general term used in metallurgy for the quantitative analysis of ores, alloys, and other metallic substances for the determination of the metals present. The term is occasionally used for analyses other than metallurgical.

Association, Molecular.—In many compounds in the liquid state, and in gases (particularly under high pressures), the molecules are combined in some way, forming complex groups or aggregates The phenomenon is a special case of polymerisation Water, ethyl alcohol, formic acid, and a large number of other compounds exhibit molecular association. The *Degree of Association* is the ratio of the average molecular weight of the liquid or gas to that of the normal (single) molecule The degree of association decreases with rise of temperature, and, as a rule, association in the liquid phase does not persist in the vapour phase.

Asymmetric Compounds.—If the spatial configuration of the molecule of a compound is such that it cannot be superimposed on its mirror image, the molecule is asymmetric and will exhibit optical rotation *See* Asymmetry, Molecular.

Asymmetric (Crystals).—*See* Triclinic.

Asymmetric Synthesis.—An asymmetric synthesis is accomplished when unequal quantities of the two enantiomorphic forms of an optically active compound are produced by a series of reactions resulting in the creation of a new centre of asymmetry. In other words, from a compound A, which may or may not be optically active, a new compound B, which must be optically active, is formed by the creation of a new asymmetric atom (usually carbon). *See* Asymmetry, Molecular.

Asymmetry, Crystal.—Certain crystalline substances exhibit optical activity, *e.g.* quartz, sodium chlorate, etc., but this property disappears on fusion or solution of the compound. The activity is therefore not due to molecular asymmetry (*q.v.*), but arises from an unsymmetrical arrangement of the molecules or

aggregates with respect to each other in the crystal structure. This arrangement is such that there is no plane of symmetry in any part of the configuration.

Asymmetry, Molecular.—In contrast to crystal asymmetry (above), many organic compounds only exhibit optical activity when in solution The optical activity in this case is ascribed to the asymmetry of the molecule. It has been found that all compounds containing a carbon atom to which is attached four different atoms or groups are optically active. The four groups are represented as being at the four corners of a regular tetrahedron, the centre of which is occupied by the carbon atom Such a configuration has no plane of symmetry (*i e.* it is asymmetric). There are only two spatial arrangements of any one such system which are not superimposable. These bear to one another the relationship of an object to its mirror image. The two forms correspond to the two optical isomers. One rotates the plane of polarisation of polarised light to the right (the dextro-isomer) and the other isomer, the laevo-, to the same extent to the left. Le Bel and, independently, Van't Hoff, first put forward this theory of the asymmetric carbon atom, and the theory is known by their joint names. Molecular asymmetry, accompanied by optical activity, is also present in compounds of polyvalent elements other than carbon; *e.g.* nitrogen, sulphur, selenium, silicon, and tin. *See* Isomerism, Optical: Enantiomorphs, and Optical Activity

Asymmetry, Absolute.—When a compound owes its optical activity to the presence of an asymmetric carbon (nitrogen, etc.) atom, the asymmetry is said to be absolute.

Asymmetry, Relative.—When the molecule of a compound is asymmetric but contains no strictly asymmetric carbon atom, the asymmetry is said to be relative; *e.g* the cis- and trans- isomers of hexahydroterephthalic acid, in which the asymmetry does not result in optical activity.

Atmolysis.—The separation of the constituents of a gaseous mixture by diffusion through a porous membrane. *See* Diffusion, and Graham's Law.

Atomic Diameter.—Regarding the atoms as spheres, then all the atoms of any one element have the same diameter (or radius) in all the crystalline compounds in which they are present; and in any crystalline compound the distance between any two atoms is the sum of the radii of the two atomic spheres. This is known as *Bragg's Law of Atomic Diameters.* The imaginary atomic sphere is known as the *Atomic Domain.* The atomic diameters vary from $1{\cdot}30 \times 10^{-7}$ mm. for nitrogen and oxygen to $4{\cdot}75 \times 10^{-7}$ mm. for caesium.

Atomic Domain.—*See* Atomic Diameter.

Atomic Heat.—The product obtained by multiplying the specific heat of an element by its atomic weight. It represents, therefore, the amount of heat required to raise the gram-atom of an element 1° C. It has been found that the atomic heats of nearly all the elements have the same value, viz, 6 4. Otherwise expressed, the thermal capacity of the atoms is the same for all elements (approximately). This is *Dulong and Petit's Law.*

Atomicity.—A term used to express the number of atoms in the molecule of an element; *e g.* argon has one and is termed monatomic; oxygen has two (*diatomic*); ozone, three (*triatomic*); and phosphorus, four (*tetratomic*). The term *Polyatomic* signifies more than one atom in the molecule.

Atomic Mass.—The mass of a hydrogen atom has been determined by measuring the value of the ratio m/e, where m is the mass and e the electrical charge (in electromagnetic units). This ratio is $1{\cdot}04 \times 10^{-4}$. The value of e is $1{\cdot}57 \times 10^{-20}$. Consequently, m is $1{\cdot}64 \times 10^{-24}$. This is the mass of a hydrogen ion. Assuming the atom to have the same mass, then the mass of an atom of hydrogen is $1{\cdot}64 \times 10^{-24}$ grams. The atomic mass of the other elements may be obtained by multiplying this value by their atomic weights. *Cf.* Atomic Weight. *See* Positive Ray Analysis.

Atomic Number.—The number expressing the position of an element in the Periodic Table (Classification), in which the elements are arranged in increasing order of atomic weight, beginning with hydrogen, 1. It is also the total number of electrons in the atom, according to the recent theories of the structure of the atom. Thus the atomic number of hydrogen is one; helium, two; lithium, three; and so on.

Atomic Radius.—*See* Atomic Diameter.

Atomic Refraction.—The specific refraction (*q v.*) of an element multiplied by its atomic weight.

Atomic Rotation.—*See* Magnetic Rotation.

Atomic Migration, Transposition.—*See* Isomerisation, and Molecular Transposition.

Atomic Volume.—The volume in ccs. occupied by the gram-atom of an element. It is obtained by dividing the gram-atom by the specific gravity of the element. It does not represent the volume occupied by an atom, since the atomic volume includes the spaces between the atoms in the molecules and those between the molecules.

Atomic Weight.—Hydrogen being the lightest known of all the elements, the value 1 was arbitrarily assigned to the weight of its atom in order to have a standard or unit by which the weights of the atoms of other elements could be expressed. Thus it was found, for example, that carbon was twelve and oxygen sixteen times heavier than hydrogen. The atomic weights 12 and 16 were therefore assigned to carbon and oxygen respectively, and so on with other elements. Since these atomic weights were largely determined by analysis of compounds, it was found more convenient to take oxygen = 16 as the standard, as practically all the elements form more or less easily analysable compounds with oxygen and few with hydrogen. It was later found that the ratio H:O was not exactly 1:16. Taking 16·00 as the atomic weight of oxygen, hydrogen is 1·008. Atomic weights are therefore purely relative numbers. The atomic weight may also be defined as the smallest amount of an element present in the molecule of any of its compounds. Atomic weights may be determined by analysis of compounds; molecular heats, isomorphism, atomic heats, homologous spectra, mass spectra, and other methods. *See* Atoms, Atomic Mass, and Isotopes.

Atomiser.—An apparatus for giving a fine jet or spray of liquid

Atoms.—Atoms have been defined as the ultimate indivisible particles of an element. By "indivisible" is meant "indivisible by chemical means." In other words, "an atom is a particle of an element whose constituent parts are held together by forces sufficiently powerful to resist rupture by any chemical means." In a purely chemical sense the definition originally given by Dalton that "an atom is the smallest part of an element which takes part in a chemical reaction" still holds good. The further definition that "the atom is the smallest part of an element which retains all the properties of the element" is really an assumption. We are not yet sufficiently acquainted with the properties of the atoms to be able to say whether these are the same as those of the element *en masse*. This assumption is made in applying some of the methods for determining atomic weight (analysis, atomic heats, etc.). Atoms may still be defined for chemical purposes as the ultimate particles of an element. The laws of chemical combination, which this definition interprets, still hold true, and the definition is independent of the internal structure of the atom. Recent views on the structure of the atom are to the effect that it is composed of an electropositive nucleus surrounded by a number of negatively charged particles (electrons), the number of these and their arrangement about the central nucleus determining the properties of the element, each element having a distinct number and arrangement of electrons. *See* Electrons, Atomic Number, Ions, and Lewis-Langmuir Theory.

Attraction, Molecular.—*See* Molecular Attraction.

Autocatalysis.—The catalysis of a reaction by one of the substances produced by the reaction; *e.g.* the hydrolysis of an ester is catalysed by hydrogen ions and is therefore autocatalysed by the acid produced during the hydrolysis. Similarly, the nitrous acid produced by the action of strong nitric acid on certain metals catalyses the latter action. *See* Catalysis.

Autoclave.—A strong vessel, generally of iron or steel, made to withstand high internal pressure. Autoclaves are employed chiefly for carrying out chemical reactions involving the use of volatile liquids at more or less elevated temperatures, and also in cases where the reaction system must be an isolated one.

Autolysis.—The disintegration of dead tissues brought about by the action of their own ferments.

Autoracemisation.—*See* Racemisation.

Autoxidation.—Many compounds which are normally unacted upon by oxygen are more or less readily oxidised in the presence of a third substance which combines with the oxygen. For example, water and oxygen do not combine to give hydrogen peroxide, but in the presence of zinc this compound is formed. The zinc is oxidised to zinc oxide, ZnO. Again, ozone is produced during the oxidation of phosphorus in air. Many oxidations may be made to take place in presence of turpentine which would not otherwise proceed; *e.g.* As_2O_3 to As_2O_5 by air. The process in many cases is probably due to the formation of a peroxide which is

sometimes termed a *moloxide* or *autoxidator*. *See* Induced Reactions.

Autoxidator.—*See* Autoxidation.

Auxiliary Valency.—*See* Valency.

Auximones.—Substances which stimulate the growth of plants.

Auxochrome (Groups).—Groups which, when introduced into a chromogen, confer dyeing properties upon it. An auxochrome therefore converts a merely coloured compound into one having a more or less pronounced affinity for textile fibres. It also has the effect of altering or modifying the colour or shade of the dyestuff. The principal auxochrome groups are OH, NH_2, OC_2H_5, and $N(CH_3)_2$. *See* Chromophore (groups) and Chromogens.

Auxoflore (Groups).—Groups which, when introduced into the molecule of a fluorescent compound, increase the fluorescence. The groups NH_2, OH, COOH, etc., have this effect. *Cf.* Bathoflore (Groups).

Avidity.—A term sometimes employed to denote the relative strengths of two acids as deduced by the amounts of them combined with a base which is present in amount insufficient to neutralise them both; *i.e.* the distribution of the base between the two acids. *See* Electrolytic Dissociation.

Avogadro's Hypothesis.—Equal volumes of all gases at the same temperature and pressure contain the same number of molecules. Since the gram-molecule of any element or compound contains the same number of molecules (the Avogadro Number, *q.v.*), it follows from the above that the gram-molecule of all gases must occupy the same volume—that is, the *molecular volume* (*molvolume*) of all gases is a constant. It is equal to 22·4 litres at N.T.P.

Avogadro's Number.—The number of molecules in the gram-molecule of any element or compound. Also termed the Avogadro constant, with the symbol N, and the Loschmidt number Z. The number has been determined by measurements of *e/m*, Brownian Movement, and other methods, and is equal to $6{\cdot}1 \times 10^{23}$.

Axial Symmetric.—A term sometimes applied to the trans- or fumaroid isomer. *See* Isomerism, Geometrical.

Axis of Symmetry.—*See* Symmetry, Crystal.

Azenes.—Compounds containing the diazo group with the formulation according to Angeli and Thiele, $-N \equiv N-$, as opposed to that of Curtius, $-N=N-$. The general formula for these compounds is $A=N \equiv N$; *e.g.* diazomethane, $CH_2=N \equiv N$; hydrazoic acid (azoimide), $NH=N \equiv N$, etc. The name azenes was proposed by Staudinger by analogy with the ketenes, $R_2C=C=O$, the $N \equiv N$ group taking the place of the $C=O$. Term not yet in general use. *See* Diazo Compounds.

Azeotropic (Mixtures).—Mixtures of liquids having a constant boiling point; *e.g.* a mixture consisting of 57% pyridine and 43% water (by weight) has a b.p. 92·6° C., that of pyridine being 115° and water 100°. A mixture of two such liquids is termed binary, and one of three ternary. An example of the latter is ethyl alcohol 18·5% (b.p. 78·3°), water 7·4% (b.p. 100°), and benzene 74·1% (b.p. 80·2°). This mixture boils at 64·85°. Azeotropic mixtures behave on distillation as a single chemical individual, the distillate having the same composition as the original liquid. The boiling points given are for 760 mm. pressure. If the pressure is altered the boiling point and composition of the mixture also vary. *Cf.* Hylotropic.

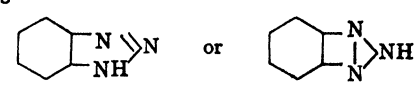
Azides.—(1) Salts of hydrazoic acid (azoimide) *e.g.* sodium azide, $NaN\langle^{N}_{N}\!\!\|$; phenyl azide, $C_6H_5N\langle^{N}_{N}\!\!\|$, etc. (also termed *triazo*benzene, etc.) The azides are also known as Azoimides. *See* Azenes.

(2) *Acid Azides.*—Compounds analogous to the acid amides (*q.v.*), but containing the group $-CO-N\langle^{N}_{N}\!\!\|$ in place of $-CONH_2$. The acid azides are prepared by the action of sodium or potassium nitrite on the hydrochlorides of acid hydrazides (*q.v.*); *e.g.* acetyl hydrazide → acetyl azide,

$$CH_3CONHNH_2.HCl+KNO_2 \rightarrow CH_3CON_3+KCl+2H_2O.$$

Azimethylenes.—Compounds of the type $R_2C\langle^{N}_{N}\!\!\|$. Term not in general use. *Cf.* Hydrazimethylenes.

Azimides, Azimines.—Compounds containing the triazole ring fused to an aromatic nucleus; *e.g.* azimmobenzene.



The *N*-hydroxy derivatives are termed *azimidols*.

Azines.—Six-membered ring compounds containing nuclear nitrogen. Those containing one N atom are *monazines*; *e.g.* pyridine, acridine, etc.; those with two are *diazines*, (1) ortho-, *e.g.* pyridazines (*q.v.*); (2) meta-, *e.g.* pyrimidines (*q.v.*); (3) para-, *e.g.* pyrazines (*q.v.*). Those containing three N atoms are termed *triazines*, and those with four, *tetrazines*. If the ring contains one oxygen atom as well as one N, it is termed an *oxazine*, one sulphur and one N, a *thiazine*. *See also* Aldazines and Ketazines. It should be mentioned that the term azine is now almost universally employed for the diazines.

Azo (Compounds).—Compounds of the type $R_1 - N = N - R_2$, where R_1R_2 are any organic radicles; *e.g.* benzeneazotoluene, $C_6H_5 - N = N - C_6H_4CH_3$. Those containing two such groups are termed *disazo* or *bisazo*. Disazo compounds are divided into primary and secondary. The primary compounds are formed by coupling two diazotised components with a third component, or a tetrazotised component with two other components Secondary compounds are formed by diazotising an amino compound already containing an azo group and coupling with a new component. Compounds containing three azo groups are termed *trisazo*, those with four *tetrakisazo*. *See* Diazo Compounds, and Coupling.

Azoimides.—*See* Azides.

Azoles.—Five membered ring compounds containing nuclear nitrogen. (1) One N atom (*monazoles*) are *pyrrole* and its derivatives, including fused ring compounds; *e.g.* indole, carbazole. (2) Two N atoms (*diazoles*), *pyrazoles* or *iminazoles* (*glyoxalines*), according to whether the N atoms are 1 : 2 or 1 : 3 :

Pyrazoles (1:2 diazole) — Iminazoles (glyoxalines) (1:3 diazoles)

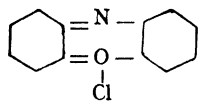
The fused ring derivatives include, *e g.*, indazole, benziminazole, etc. (3) Three N atoms (*triazoles*); the term *osotriazole* is sometimes applied to triazoles with the three N atoms adjacent (*cf.* Azimides). (4) Four N atoms (*tetrazoles*). (5) Five membered rings containing one N and one O atom are termed *oxazoles*. If the N and O are adjacent they are known as *isoxazoles*. (6) Those containing two N atoms and one O atom are termed *oxdiazoles*; if the grouping of these three atoms is =N—O—N= they are known as *furazans* or *azoxazoles*. (7) With N and sulphur in the ring, the compounds are termed *thiazoles*.

Azomethines (Schiff's Bases).—Compounds prepared by the interaction of aldehydes and amines, and having the general formula $R_1.CH = N.R_2$. The group $- CH = N -$ is here termed the *azomethine* group.

Azotometer.—*See* Nitrometer.

Azoxazoles.—*See* Azoles.

Azoxonium (Compounds).—A name proposed by Kehrmann for the salts of the oxazines in which the negative radical is attached to the oxygen; *e g.*



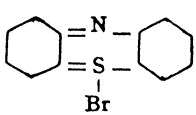
Diphenazoxonium chloride.

Azoxy (Compounds).—Compounds of the type

They are usually obtained by the reduction of nitro-compounds; *e.g.* nitrobenzene, $C_6H_5.NO_2$, gives azoxybenzene, $C_6H_5.N{<}^{O}{>}N.C_6H_5$.

The group (or) is termed the azoxy group.

Azthionium (Compounds).—A name proposed by Kehrmann for the salts of the thiazines in which the negative radical is attached to the sulphur; *e.g.*



Diphenazthionium bromide.

B

Babo's Law.—*See* Raoult's Law.

Back E.M.F.—*See* Polarisation (Electrical).

Bacteriostatic Power.—The power of certain reagents to prevent the growth of bacteria.

Balanced Actions (Reactions).—*See* Chemical Equilibrium, and Mass Action, Law of.

Balmer Series.—*See* Balmer Spectrum.

Balmer Spectrum.—The wave lengths, λ, of the lines of the hydrogen spectrum can be deduced very accurately by means of the formula

$$\lambda = 3647 \times \frac{m^2}{m^2-4},$$

known as the Balmer Formula Giving values of 3, 4, 5, etc., up to 16, to *m*, a series of spectral lines, the Balmer Series, is obtained. These lines are in the visible spectrum, and they constitute the so-called Balmer Spectrum. In addition to the above lines there are a number of other very fine lines in the hydrogen spectrum to which the Balmer Formula does not apply.

Band Spectrum.—*See* Spectrum, Emission.

Bang's Method.—The estimation of glucose in blood. The glucose is extracted in KCl solution acidified with acetic acid, and treated with alkaline copper solution containing K_2CO_3, KCl, and $KHCO_3$. The reduced copper is estimated by titration with standard iodine.

Barcroft and Haldane's Method.—Oxygen in blood is estimated by treating the blood with potassium ferricyanide and ammonia. The oxygen is liberated and the volume measured

Barfoed's Reagent.—For the detection of dextrose in presence of maltose and lactose. A solution of cupric acetate (1 part) in water (15 parts) is made ; to 200 parts of this solution 5 c.cs. of 38% acetic acid are added. The solution to be tested is then boiled with this reagent, when, if dextrose is present, cuprous hydroxide is formed.

Bases.—Bases may be classed, in general, as compounds which give hydroxyl ions in aqueous solution. They react with (combine, neutralise) acids with formation of salts. The inorganic bases are the hydroxides of certain metals, such as those of the alkali and alkaline earth metals (*q.v.*), ammonium hydroxide, etc. The organic bases are the aliphatic and aromatic amines, cyclic nitrogen compounds (pyridine, quinoline, carbazole, pyrrol, etc.). The bases are classified as primary, secondary, and tertiary, just as are the amines (*see also* Quaternary Bases). The strength of a base is measured by the amount of hydroxyl ions it furnishes in solution ; *e.g.* KOH and NaOH are strong bases ; NH_4OH and the organic bases generally are weak bases. Bases with one hydroxyl are termed *monacid* bases, those with two *diacid* bases, and so on. *See* Alkalis, Amines, Amphoteric Compounds, and Hydrolysis.

Basicity.—A term used to express the number of hydrogen atoms of an acid which are replaceable by a metal. Acids which have only one such hydrogen atom are termed *monobasic acids* (*e.g.* HCl, HCN, the monocarboxylic acids, etc.). Those with two are *dibasic* (*e.g.* H_2SO_4 and the dicarboxylic acids). Those with three are *tribasic* (*e.g.* H_3PO_4, H_3BO_3, citric and other bicarboxylic acids). Those with four are *tetrabasic* (*e g* $H_4Fe(CN)_6$). Those with more than one replaceable hydrogen atom may be classed together as *polybasic*. *See* Carboxyl.

Basic Salts.—If a di- or tri- acid base is only partially neutralised by an acid, a compound results which retains some basic properties. These are classed as Basic Salts ; *e.g.* lead hydroxide, $Pb(OH)_2$, gives basic lead nitrate, $Pb(OH)NO_3$. In many cases the basic salts may be represented as molecular compounds of free base and normal salt ; *e g.* basic lead carbonate, $Pb(OH)_2.2PbCO_3$. Many basic salts of this type are produced by hydrolysis of the normal salts *See* Bases, Salts, and Hydrolysis.

Basylous.—A term recently proposed for those atoms or groups which tend to lessen the acid character of a molecule ; *e.g.* NH_2, $N(CH_3)_2$, etc.

Bathochromes.—The introduction of certain substituents into the molecule of an organic compound has the effect of shifting the bands in the absorption spectrum of the compound in the direction, ultra-violet → visible spectrum → infra-red The colour of the compound thus passes through the range, colourless → yellow → orange → red → violet → blue → green, the actual colour depending on the extent and nature of the absorption. Such substituents are termed Bathochromic (Groups), or Bathochromes ; *e g.* NO_2, NHR, Cl, etc. The phenomenon is termed Bathochromy. The reverse process, in which the absorption is shifted from the red end of the spectrum towards the violet, is termed *hypsochromy*, and the groups producing it *hypsochromic groups*, or *hypsochromes*. *Cf.* Chromophore (Groups).

Bathoflore (Groups).—This name is given to certain groups which, when introduced into the molecule of a fluorescent substance, diminish the fluorescence ; *e.g.* NO_2, CO, Cl, etc., have this effect. *Cf.* Auxoflore (Groups).

Beaumé Hydrometer.—There are two hydrometers of the Beaumé type—one for liquids lighter than water and another for those heavier than water. In the first the stem has a zero mark at the bottom for a solution of 90 parts

water and 10 parts sodium chloride (at 17·5° C.), and another mark further up for pure water, which is marked 10. The interval between these two marks is divided into 10 equal divisions, which are then continued to the top of the scale. In the second the zero is for pure water and is at the top of the stem. The immersion point for a solution of 85 parts water and 15 parts sodium chloride is marked 15 on the stem, and the interval between these divided into 15 equal divisions, which are continued downwards on the stem. Specific gravity taken by means of these hydrometers is termed Degrees Beaumé, or simply Bé.

Beckmann Method.—The determination of molecular weight by the boiling point elevation or freezing point depression in special type of apparatus designed by Beckmann. *See* Raoult's Law.

Beckmann Reaction.—The conversion of ketoximes into substituted amides, according to the scheme,

$$\begin{array}{ccccc} R.C.R' & & R.C.OH & & R.C:O \\ \| & \rightarrow & \| & \rightarrow & | \\ N.OH & & N.R' & & NHR' \end{array}$$

e.g. acetophenoneoxime, $C_6H_5C(:N.OH).CH_3$, gives acetanilide, $C_6H_5NHCOCH_3$. The change is usually brought about by the action of PCl_5; other reagents, such as acetic and mineral acids, may be used. It is the syn-oximes which behave in this way. In the unsymmetrical oximes in general that group richest in carbon is the one which migrates to the nitrogen atom. This reaction is also variously designated as the Beckmann Change, Inversion, Rearrangement, Transformation, or Transposition.

Becquerel Rays.—Radioactive rays produced by uranium ores. Discovered by Becquerel in 1896. Now known as γ-rays. *See* Radioactivity.

Beer's Law.—In light absorption the rays pass through the same number of molecules of a substance in either dilute or concentrated solutions, provided the thickness of the layer of solution is kept directly proportional to the degree of dilution. For example, the absorption is the same if the concentration is doubled and the thickness of the layer halved.

Beilstein Test.—A test for the presence of halogens in organic compounds. It consists in heating the substance on copper oxide in a Bunsen flame. If halogens are present the flame is coloured bright green.

Benz- (Benzo-).—A prefix used to denote the presence in a molecule of the phenyl or phenylene radical; *e.g.* benziminazole (*q.v.*), and benzophenone, $C_6H_5.CO.CH_3$.

Benzal (Radical).—The group $C_6H_5CH=$; *e.g.* benzal chloride, $C_6H_5CHCl_2$; benzalacetone, $C_6H_5CH:CH.CO.CH_3$. The term benzylidene is also commonly used for this radical.

Benzeins.—Triphenylcarbinols containing two hydroxylated benzene rings; *e.g.* $C_6H_5.C(OH).(C_6H_4.OH)_2$.

Benzenoid.—A term applied to the characteristic structure or properties of the benzene ring. Compounds containing one or more benzene (naphthalene, etc.) rings are termed benzenoid, the term being synonymous with aromatic in this case. *Cf* Quinonoid

Benzenyl (Radical).—The group $C_6H_5.C\equiv$.

Benzidine Transposition.—The molecular rearrangement of hydrazobenzene to *p*-diaminodiphenyl (benzidine) by the action of mineral acids,

$C_6H_5NH.NHC_6H_5 \rightarrow NH_2C_6H_4.C_6H_4.NH_2$.

Also known as the Benzidine Change, Conversion, and Rearrangement. *Cf.* Semidine Transposition, and Ortho-benzidine Transposition.

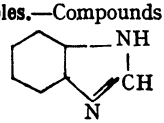
Benzilic Acid Rearrangement.—The conversion of benzil to benzilic acid by the action of alkalis:

$C_6H_5CO.COC_6H_5 \rightarrow (C_6H_5)_2.C(OH).COOH$.

Cf. Pinacone-Pinacoline Rearrangement.

Benzilyl (Radical).—The group $(C_6H_5)_2.C(OH)-$.

Benziminazoles.—Compounds of the type



See Azoles

Benzohydryl (Radical).—The group $(C_6H_5)_2CH-$.

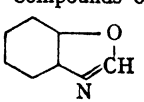
Benzoin Condensation.—The condensation of two molecules of an aromatic aldehyde under the influence of KCN, according to the following scheme:

$$R\,CHO + OHC.R \rightarrow R\,CH(OH).CO.R.$$

See Aldol Condensation, and Aldolisation.

Benzologic.—*See* Allologic.

Benzoxazoles.—Compounds of the type



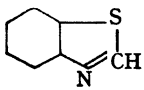
See Azoles.

Benzoyl (Radical).—The group $C_6H_5.CO-$. The acid radical of benzoic acid. The abbrevia-

tion Bz is sometimes used in formulæ; *e.g.* benzoyl-aminoacetic acid, $BzNH.CH_2.COOH$. *See* Hippuryl.

Benzoylation.—The introduction of the benzoyl group into the molecule of an organic compound. The substitution is generally in the OH or NH_2 groups; *e.g.* phenol, $C_6H_5.OH \rightarrow$ phenyl benzoate, $C_6H_5O.COC_6H_5$; aniline, $C_6H_5.NH_2 \rightarrow$ benzoylaniline (benzanilide), $C_6H_5NH.COC_6H_5$. Benzoylation is usually carried out by means of benzoyl chloride, C_6H_5COCl. *See* Schotten-Baumann Reaction.

Benzthiazoles.—Compounds of the type



See Azoles.

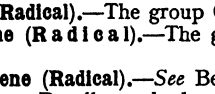
Benzyl (Radical).—The group $C_6H_5.CH_2-$.

Benzylene (Radical).—The group $-C_6H_4.CH_2-$.

Benzylidene (Radical).—*See* Benzal.

Beryllates.—Beryllium hydroxide combines with strong alkalis forming salts termed beryllates; *e.g.* Na_2BeO_2. Also termed beryllonates. *Cf.* Zincates.

Betaines.—Compounds of the type

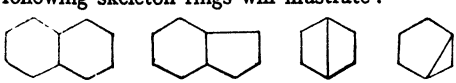


Beta (Position), (β-position), etc.—*See* Table of Symbols, p. 157.

Beta-Rays (β-Rays).—*See* Radioactivity.

Bial's Reagent.—A reagent for the detection of pentoses. One gram of orcinol is dissolved in 500 c.cs. of 30% HCl to which 30 drops of 10% ferric chloride have been added. On adding this solution drop by drop to the boiling solution containing pentose a green coloration is developed.

Bicyclic Compounds.—Organic compounds whose molecules contain two fused rings (*q.v.*) or bridged rings (*q.v.*). There are a large number of different types of both carbocyclic and heterocyclic bicyclic compounds. The following skeleton rings will illustrate:



naphthalene, quinoline, benziminazole, pinene, camphor, and atropine are examples of bicyclic compounds. *See* Cyclic Compounds, Endocyclic, and Polycyclic.

Bimolecular Reaction.—A chemical reaction in which two molecules react to give one or more other molecules. Such a reaction may be expressed by the general equations

$$A + B = C(+ D, \text{etc.}), \text{ or}$$
$$2A = B(+ C, \text{etc.}),$$

where A, B, etc., represent a molecule each of the compounds A, B, etc.; *e.g.*

$$CH_3.COOC_2H_5 + NaOH = CH_3.COONa + C_2H_5.OH.$$
$$2HI = H_2 + I_2$$

See Chemical Equilibrium, and Reaction Velocity.

Binary Compounds.—Compounds containing only two elements in the molecule; *e.g.* HCl, HBr, H_2S (binary acids); NaCl, $CaBr_2$, As_2S_3 (binary salts).

Binary Electrolytes.—Compounds which furnish two ions in aqueous solution; *e.g.* all monobasic acids and monacid bases. *Cf.* Amphoteric Compounds.

Binary Mixtures.—Solid, liquid, or gaseous mixtures containing two constituents.

Binary Systems.—Systems of two components. *See* Phase Rule.

Biocatalysts.—Substances which accelerate the growth of living organisms.

Biocolloids.—Colloids produced in living organisms (plants and animals); *e.g.* glutins, albumins, proteins, etc. *See* Colloidal State.

Biogen Theory.—A theory which postulates living matter as composed of large molecules containing a permanent nucleus to which are attached a large number of branch or side chains. According to this theory, biochemical reactions take place by simpler molecules, such as those of the sugars, aminoacids, etc., becoming part of the biogen molecule, and thus being liable to undergo reactions which they would not experience otherwise (*i.e.* apart from the biogen).

"Biological" Blood Test.—*See* Bordet Reaction.

Bioluminescence.—Luminescence produced by living organisms, such as that of the fire-fly.

Bioses.—The two-carbon sugars. Actually, there is only one, viz. glycollic aldehyde, $CH_2OH.CHO$. *See* Sugars.

Biphenylene.—*See* Diphenylenes.

Bipolar Electrode.—A double electrode, one half or side of which is anode and the other cathode.

Birefringence.—Double refraction of light.

Birotation.—*See* Mutarotation.

Bisazo.—*See* Azo.

Bisdiazo.—*See* Diazo.

Bismuthines.—Organic derivatives of bismuthine, BiH_3; *e.g.* trimethylbismuthine, $Bi(CH_3)_3$. *Cf.* Amines, and Arsines.

Bismuthyl.—The radical OBi—.

Bitertiary.—A term indicating the presence of two tertiary atomic groupings in the molecule; *e.g.* bitertiary glycol, $R_1R_2C(OH).C(OH).R_1R_2$; bitertiary amine, $R_1R_2N.CH_2.CH_2.CH_2.NR_1R_2$, where R_1, R_2 are alkyl or aryl radicals.

Biuret Reaction.—When a solution of biuret, $NH_2.CO.NH.CO.NH_2$, is treated with copper sulphate and then caustic potash, a violet coloration is produced. The test is very sensitive for other bodies containing the $NH_2.CO.NH.CO-$ group, such as amino-acids, proteins, etc.

Bivalent.—*See* Valency.

Bivariant (Systems).—A heterogeneous equilibrium system having two degrees of freedom. *See* Phase Rule.

Black's Reaction.—A test for β-hydroxybutyric acid in urine. A rose coloration is produced on addition of a dilute solution of ferric chloride containing a little ferrous chloride.

Blagden's Law.—*See* Raoult's Law.

Blaise Reaction.—Synthetic reactions carried out by means of mixed organometallic derivatives of zinc, such as CH_3ZnI, C_2H_5ZnI, etc. The reaction is important for the synthesis of ketonic compounds. The reaction may be simplified thus:

$$R\,COCl + IZnCH_3 \rightarrow R.CO\,CH_3 + ZnICl,$$

where R is an aliphatic group. A large variety of saturated and unsaturated mono- and di-ketones, ketols, ketonic acids, etc., may be prepared in this way. *See* Cycloacetals

Boettger's Test.—A test for glucose. Bismuth subnitrate is reduced to metallic bismuth in presence of sodium carbonate.

Boiling Point (Elevation) Method.—A method for determining molecular weights. *See* Raoult's Law.

Bolometer.—A very sensitive platinum resistance thermometer. It will register temperature differences of a millionth of a degree C.

Bonds.—*See* Valency, Molecules, and Formulæ.

Bordet Reaction.—A test for human blood. It depends on the fact that the blood serum of an animal into which has been injected the blood of another animal of different species develops the property of agglutinating and dissolving erythrosites similar to those injected, but does not exert this action on erythrosites of any other species. Human blood may therefore be distinguished from that of animals by this test.

Borines.—A name sometimes given to the alkyl compounds of boron; *e.g.* triethyl borine, $(C_2H_5)_3.B$. Analogous to amines, phosphines, etc. (*q.v.*).

Boryl (Radical).—The group OB—.

Bouveault-Blanc Reaction.—The reduction of esters to alcohols by means of metallic sodium, $-COOR \rightarrow CH_2OH$; *e.g.* phenylacetic ester to phenylethyl alcohol,

$$C_6H_5CH_2COOC_2H_5 \rightarrow C_6H_5CH_2CH_2OH.$$

Boyle-Mariotte's Law.—*See* Boyle's Law.

Boyle's Law.—The product of the pressure and volume of a given mass of gas is a constant at constant temperature. It is expressed by the equation

$$PV = K,$$

when P is the pressure, V the volume, and K a constant. Gases show considerable deviations from this law at high pressures. It is also known as the Boyle-Mariotte Law.

Bragg's Law.—*See* Atomic Diameter.

Branched Chains.—Acyclic or open-chain hydrocarbons (containing at least one carbon atom directly united to three or four other carbon atoms, thus giving a branched or forked structure to the carbon skeleton; *e.g.*

Isobutane - - - $\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!CH.CH_2$;

Isoprene - $\begin{matrix}CH_3\\CH_2\end{matrix}\!\!>\!C-CH=CH_2$;

Tertiary Heptane $\begin{matrix}CH_3\\CH_3-\\CH_3\end{matrix}\!\!>\!C.CH_2.CH_2.CH_3$, etc.

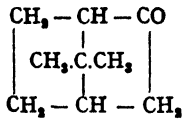
Similar structures may be present in the side chains of aromatic compounds *See* Side Chains, Isomerism (Chain), and Paraffins.

Bravais' Rule.—The rate of growth normal to a crystal face is a minimum for those planes which are densest in atoms

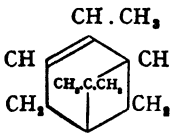
Bridged Rings.—Carbocyclic or heterocyclic rings, two of the atoms of which are connected through one or two other atoms. The connecting atom or atoms (usually groups) is called a bridge or bridge-linking. The following skeletons will illustrate:

where the * is some atomic grouping. The

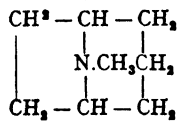
following are examples of typical bridged-ring compounds:



Camphor



Pinene



Tropane

See Bicyclic, and Endocyclic.

Bridge Elements.—The elements of the first short series of the Periodic Classification, viz. helium, lithium, beryllium, boron, carbon, nitrogen, oxygen, and fluorine.

Brodie's Reaction.—The treatment of graphite with potassium chlorate and concentrated nitric acid at 100°. This treatment gives a yellow substance (graphitic acid), and serves to distinguish graphite from the other forms of carbon.

Bromamides.—*See* Hofmann's Reaction.

Bromhydrins.—*See* Halohydrins.

Bromination.—*See* Halogenation.

Bromion.—The bromine ion, Br'. *See* Ions.

Bromyl.—A term sometimes used for bromine in compounds where it acts as an electropositive element; *e.g.* in bromamides. *See* Hofmann's Reaction.

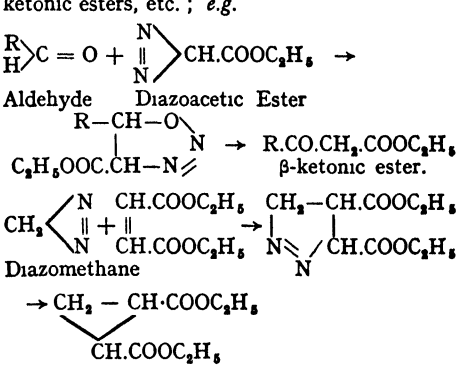
Brownian Movement.—Fine particles of a substance suspended in a liquid medium are in constant and rapid vibratory motion. This was first observed in 1827 by Brown, the eminent botanist, in the case of pollen grains suspended in water. This movement is shown by particles of less than 10^{-3} cms. diameter, provided the viscosity of the liquid medium is not too great. As the particles decrease in size the rapidity of the movement increases. The motion is due to bombardment of the particles by the molecules of the liquid medium. The molecules of a gas vibrate in a similar manner. *See* Colloidal State, and Ultramicroscope.

Brücke's Reagent.—A precipitating reagent for proteins consisting of a solution of potassiomercuric iodide in water.

B.Th.U.—British Thermal Unit. The amount of heat required to raise one pound of water 1° F. (= 252 calories).

Bucherer Reaction.—(1) The conversion of aromatic amines to the corresponding hydroxy compounds by the action of alkali bisulphites, followed by hydrolysis; *e.g.* naphthylamine → naphthol. (2) The conversion of aromatic hydroxy compounds to the corresponding amines by the action of ammonia and alkali bisulphites (or ammonium sulphite); *e.g.* naphthol → naphthylamine. Aromatic amines may be used in place of ammonia, giving aryl substituted amines.

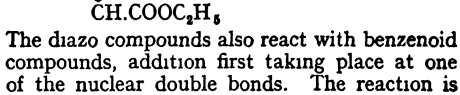
Buchner Reaction.—The reaction between aliphatic diazo compounds and compounds containing the unsaturated groupings C=C, or C = O in the molecule. Addition compounds are first formed, and these are then decomposed with liberation of nitrogen, giving ketones, ketonic esters, etc.; *e.g.*



Aldehyde Diazoacetic Ester

β-ketonic ester.

Diazomethane



The diazo compounds also react with benzenoid compounds, addition first taking place at one of the nuclear double bonds. The reaction is also known as the Buchner-Curtius Reaction.

Buffer Action.—*See* Buffer Solutions.

Buffer Solutions.—Solutions of certain salts, such as the alkali acetates, borates, phosphates, etc. Addition of strong acids or alkalis to these solutions causes only very small changes in the hydrogen ion concentration. A range of colours can thus be obtained by the addition of suitable indicators to a series of such solutions, and they thus serve as reliable standards for comparison

with other solutions whose P_H values are to be determined. Salts which prevent appreciable changes in hydrogen ion concentration of solutions of acids or alkalis are said to exert a buffer action.

Burette.—A tall, narrow, cylindrical glass vessel, graduated in c.cs. and tenths of a c.c., provided with a tap and delivery tube. It is used for delivering known volumes of standard solutions in volumetric analysis.

Butenyl (Radical).—The group $CH_3.CH_2.CH=CH-$, (1), or $CH_3.CH=CH.CH_2-$, (2).

Butyl (Radical).—The group $CH_3.CH_2.CH_2.CH_2-$.

Butylidene (Radical).—The group $CH_3.CH_2.CH_2CH=$.

Butyro-.—*See* Butyryl.

Butyryl (Radical).—The group $CH_3CH_2.CH_2.CO-$. The acid radical of butyric acid. Compounds containing this group in the molecule sometimes have the prefix *butyo-*. *See* Lactones

Buzyl (Buzylene).—*See* Diazo-hydrazo (Compounds).

Bz.—*See* Benzoyl.

C

C°.—Temperatures on the centigrade scale.

Cacodyl (Radical).—The group $-As(CH_3)_2$, dimethyl arsine radical. *See* Arsines.

Cailletet and Mathias, Law of.—In a liquid — vapour system the mean density of liquid + vapour at a given temperature $t°$ is given by the expression

$$S_m = S_0 + \alpha t,$$

where S_m is the mean of the two densities at the temperature $t°$, S_0 the mean at 0°, and α is a constant. It is a linear expression, and is also known as the Law of the Rectilinear Diameter.

Cal. (cal.).—*See* Calorie.

Calcareous.—Containing calcium carbonate or oxide (lime). Generally applied to minerals containing the former, such as chalk, limestone, and marble.

Calcification.—A pathological term denoting the formation of deposits of calcium salts in the connective tissues of the body.

Calcination.—The strong heating of mineral substances in air, usually with production of an oxide; *e.g.* many metals yield in this way metallic oxides; and metallic carbonates, such as those of calcium and magnesium, yield the corresponding oxides, lime and magnesia. The oxide, etc., thus obtained was sometimes called a **calx.**

Calcometer.—An instrument for measuring the heat loss of a wire coil maintained at constant temperature. The heating of the coil is done, and the measurements made, electrically. The loss of heat of the coil varies with the condition of the surrounding atmosphere. The dependence of the rate of cooling of a body on the atmospheric condition can thus be measured.

Calomel Electrode.—A standard half-element (single electrode) consisting of pure mercury in contact with normal potassium chloride solution saturated with calomel, (Hg_2Cl_2). This gives a constant electrode potential of 0·56 volt. If decinormal KCl is used, the potential is 0.61 volt.

Caloric Quotient.—The amount of heat in calories produced by a living organism per milligram of oxygen consumed by the organism

Calorie.—The heat unit in the c.g.s. system. It is defined as the amount of heat required to raise one gram of water at 15° C. through one degree C° (temperatures measured on the air thermometer). It is generally designated by the abbreviation cal. or kal. Large amounts of heat are measured in terms of 1,000 cal; *i.e.* the amount of heat required to raise 1,000 grams (kilogram) of water from 15° to 16° C. It is abbreviated to Cal. or Kal. The former (cal.) is also termed a small calorie or gram-calorie, and the latter a large or big calorie or kilogram-calorie. Since the specific heat of water varies with the temperature, the value of the calorie will also vary. The amount of heat required to raise one gram of water from 0° to 1° C. is termed a zero-calorie and is 1·008 times the standard gram-calorie. Another calorie unit is one hundredth of the amount of heat required to raise one gram of water from 0° to 100° C. This is termed the mean calorie.

Calorific Value.—The amount of heat given out by the combustion of unit quantity of a combustible substance, under given conditions. A term largely used in the evaluation of fuels. It is generally expressed in calories per gram, Calories per kilogram, or British Thermal Units (B.Th.U.) per pound, or in the case of gases, such as coal or producer gas, per litre, cubic metre, or cubic foot. *See* Heat of Combustion

Calorimeter.—An apparatus for measuring the evolution or absorption of heat in a reaction

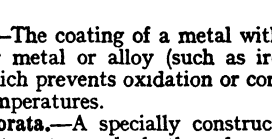
Calorimetry.—The measurement of the evolution or absorption of heat in a reaction, such as heat of combustion (*q.v.*) and heat of neutralisation (*q.v.*).

Calorisation.—The coating of a metal with a film of another metal or alloy (such as iron-aluminium), which prevents oxidation or corrosion at high temperatures.

Camera Inodorata.—A specially constructed box or compartment in which the odours of perfumes may be studied and compared without contamination from odours in the room. *See* Olfactometry.

Camphanyl (Radical).—The group $C_{10}H_{17}$ —, from camphane.

Camphoceanic (Ring).—The ring



present in compounds of the camphor group.

Camphoroyl (Radical).—The group

$$C_8H_{14}\begin{matrix}CO-\\CO-\end{matrix}$$

The radical of camphoric acid.

Camphoryl (Radical).—The group $C_{10}H_{17}O$— from camphor.

Canal Rays.—Positive rays (*q v*).

Cannizaro's Reaction.—The conversion of an aldehyde to the corresponding alcohol and acid by the action of caustic potash or soda. Two molecules of the aldehyde yield one molecule each of the alcohol and acid (Na or K salt); *e g.* benzaldehyde gives benzyl alcohol and benzoic acid,

$$2C_6H_5.CHO \xrightarrow{KOH} C_6H_5CH_2OH + C_6H_5COOK;$$

valeraldehyde gives valeric acid and amyl alcohol,

$$2C_4H_9\,CHO \xrightarrow{NaOH} C_4H_9.COONa + C_4H_9\,CH_2OH.$$

Capacity Factor.—All forms of energy may be regarded as the product of two factors representing quantity and intensity. The one representing quantity is termed the capacity factor The other, which represents force, strength, or intensity, is termed the intensity factor; *e g.* in heat energy the capacity factor is the quantity of heat (calories) and the intensity factor is temperature; in electrical energy the capacity factor is quantity of electricity (coulombs), and the intensity factor is voltage (volts).

Capillary Analysis.—A method of separating and detecting the constituents of a mixture by the differences in their rate of absorption and diffusion in certain substances, such as filter paper.

Capillary Electrometer.—An apparatus used in the determination of electromotive force, for obtaining the point of balance on the bridge wire (Wheatstone Bridge method). A capillary tube contains the junction between mercury and a sulphuric acid solution. A difference in potential between these two liquids alters the surface tension at the mercury-sulphuric acid surface and causes a movement of the junction meniscus. At balance there is no movement.

Capro-.—*See* Caproyl.

Caproyl (Radical).—The group

$$CH_3\,(CH_2)_4.CO-.$$

The acid radical of caproic or *n*-hexoic acid. Compounds containing this group in the molecule sometimes have the prefix capro-.

Capryl (Radical).—The normal paraffin group

$$CH_3\,(CH_2)_6CH_2-.$$

Caprylyl (Radical).—The group

$$CH_3\,(CH_2)_6.CO-.$$

The acid radical of caprylic acid.

Carbamides.—Derivatives of urea (carbamide); *e g* ethyl-urea, $C_2H_5NH.CO.NH_2$.

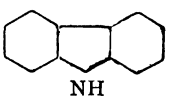
Carbamido (Radical).—The group

$$NH_2\,CO\,NH-.$$

Carbamines.—*See* Carbylamines.

Carbamyl (Radical).—The group $NH_2.CO-$.

Carbazoles.—Derivatives of carbazole:



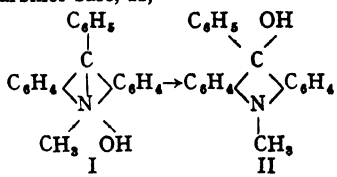
Carberines.—The hypothetical ortho-carboxylic acids of the constitution $R\,C(OH)_3$. The carboxylic acids are derived from these by elimination of one molecule of water, giving R COOH

Carbethoxy (Radical).—The group

$$-COOC_2H_5.$$

Carbimides.—Alkyl or aryl isocyanates of the general formula R.N : CO; *e.g.* ethyl carbimide, C_2H_5N : CO.

Carbinol Bases.—Certain basic organic compounds having a hydroxyl group in combination with carbon instead of with nitrogen as in the nitrogen or ammonium bases. They are derived from the nitrogen bases by the migration of the OH group from the nitrogen to carbon; *e g.* phenylmethylacridinium hydroxide, I, gives the carbinol base, II,



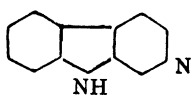
Carbinols.—Alkyl or aryl derivatives of methyl alcohol, $CH_3.OH$; *e.g.* trimethyl carbinol, $(CH_3)_3.C.OH$, diphenyl carbinol, $(C_6H_5)_2CH.OH$, etc.

Carbo-.—A prefix sometimes employed to denote the presence of a —CO— group in the molecule, particularly when this is the fundamental or central grouping. Sometimes the term is extended to include C or COOH.

Carbocyclic (Compounds).—Cyclic compounds containing only carbon atoms in the ring. The term covers all homocyclic carbon compounds such as polymethylenes, cyclo-olefines, benzenes, naphthalenes, anthracenes, etc.

Carbohydrates.—Compounds of carbon, hydrogen, and oxygen in which the hydrogen and oxygen are present in the same atomic ratio as in water. All carbohydrates therefore have the general formula $C_n(H_2O)_m$ or $C_nH_{2m}O_m$. The name has come to be reserved for the mono-, di-, and polysaccharoses (*q v.*) The carbo hydrates constitute a large and important class of naturally occurring compounds. *See* Sugars, Hemicelluloses, Starches, Gums, Pectins, and Mucilages.

Carbolines.—Derivatives of carboline:



Carbomethenes.—Ketenes (*q v.*)

Carbomethoxy (Radical).—The group $-COOCH_3$

Carbonaceous.—A name given to substances rich in carbon, such as coal, coke, lignite, charcoal, etc.

Carbonisation.—The treatment of substances rich in carbon (either free or combined) in order to produce a more or less pure form of carbon. Destructive distillation is the commonest process of this type, as, *e.g.*, in the carbonisation of coal, wood, etc. *See* Destructive Distillation

Carbonium Compounds.—In certain triarylmethyl halides, $Ar_3C.X$ (X = halogen), the halogen behaves in some ways differently from that in the ordinary alkyl halides; *e.g.* the chlorine atom in triphenylmethyl chloride, $(C_6H_5)_3C.Cl$, is more reactive than that in methyl chloride, CH_3Cl, or tribenzoylmethyl chloride, $(C_6H_5CO)_3C.Cl$. Thus, it forms addition compounds such as $(C_6H_5)_3C.Cl.SnCl_4$, $(C_6H_5)_3C.Cl.AlCl_3$, etc., and the chlorine has a tendency to ionise. There would appear to be a weakening of the valency between the carbon and halogen. This valency is termed a *carbonium valency*, and is conventionally represented by a wavy line, ~~. Thus triphenylmethyl chloride is written $(C_6H_5)_3C$ ~~ Cl. Compounds of this type are called carbonium compounds. According to Werner's theory of valency the halogen is in the outer or dissociable zone of the central methane carbon atom and possesses residual valency. The corresponding bases, such as $(C_6H_5)_3C.OH$, form highly coloured salts in acid solution, the so-called *carbonium salts*. *See* Halochromy.

Carbonium Salts.—*See* Carbonium Compounds

Carbonium Valency.—*See* Carbonium Compounds.

Carbons.—A name used as a familiar designation of carbon electrodes of electric arcs (lamps, furnaces).

Carbonyl Compounds.—In general, compounds containing the carbonyl radical as the chief group; *i e* derivatives of carbon monoxide; *e g* carbonyl chloride, $COCl_2$; urea, $CO(NH_2)_2$ The term may be extended to include amides, R CO NH_2, acid chlorides R CO Cl, ketones, R.CO.R, etc *See* Carbonyls.

Carbonylene Compounds.—A name proposed for all derivatives of :CO, such as ketenes, $R_2C : CO$, isocyanates, RN : CO, etc., where the CO is present as the unsaturated group = C : O.

Carbonyl (Radical).—The group >C = O. It is one of the most reactive and important of all the organic radicals, and is present in aldehydes, ketones, carboxylic acids, quinones, amides, etc

Carbonyls.—Compounds of certain metals with carbon monoxide; *e g.* nickel carbonyl, $Ni(CO)_4$, and iron carbonyls, $Fe(CO)_4$, $Fe(CO)_5$, etc These compounds are gases.

Carboxylases.—Enzymes which act by removing carboxyl groups (as CO_2) from keto- and amino-acids.

Carboxylic Acids.—Organic acids which owe their acid properties to the presence of carboxyl groups. Those with one carboxyl group are termed monocarboxylic (*e g.* acetic, $CH_3.COOH$; benzoic, $C_6H_5.COOH$). Those with two are dicarboxylic (*e g.* succinic, $HOOC.CH_2.CH_2.COOH$; phthalic, $C_6H_4(COOH)_2$), and so on.

Carboxyl (Radical).—The group

The acid group of the organic acids.

Carbylamines.—Alkyl or aryl isocyanides having the general formula R.N : C ; *e.g.* ethyl carbylamine, C_2H_5N : C. They are also termed *carbamines.*

Carius' Method.—A method for estimating halogens and sulphur in organic compounds. For the former, the compound is heated in a sealed tube with fuming nitric acid and silver nitrate. Silver halide is formed and estimated. For sulphur, the compound is heated with fuming nitric acid in the same way. The sulphur is oxidised to sulphuric acid and is estimated as barium sulphate.

Carletti's Indicator. — A reduced phenolphthalein made by boiling phenolphthalein with caustic potash and zinc dust till colourless.

Carminatives.—Substances which, taken internally, help to expel gas from the stomach by stimulating the movement of its contents.

Carotinoids.—A class of chromolipoids (*q.v.*) related in constitution and source to carotin, a red hydrocarbon occurring along with chlorophyll in green plants

Carrel-Dakin Solution.—A neutral solution of sodium hypochlorite used in the treatment of wounds

Catabolism.—The breaking down of complex into simpler compounds in the living organism. *See* Metabolism.

Catalyser.—*See* Catalysis

Catalysis.—Many reactions which proceed very slowly under ordinary conditions have their velocities increased in the presence of certain substances which are in most cases chemically unchanged at the end of the reaction. Such reactions are said to be catalysed, and the phenomenon is termed catalysis. The number of such reactions known is very large, and numerous substances can act as catalysts. In some cases the increase in the velocity of the reaction is directly proportional to the amount of catalyst present, as, *e g.*, the hydrolysis of cane sugar to dextrose by strong acids (HCl) in dilute aqueous solution. In this case the rate of hydrolysis is proportional to the concentration of hydrogen ions. In other cases a very small amount of catalyst is capable of influencing the reaction between indefinitely large amounts of the reacting substances ; *e.g.* the decomposition of hydrogen peroxide by platinum, and the catalysis of the $SO_2 \rightarrow SO_3$ reaction by the same metal. It is generally held that a catalyst only promotes the velocity of a reaction, but does not initiate one, and that in a reaction which reaches an equilibrium the presence of a catalyst does not alter the equilibrium point, but only accelerates the rate at which this equilibrium point is reached.

Catalysed reactions are conveniently divided into two classes, viz. homogeneous and heterogeneous. In the former the whole system constitutes one homogeneous phase ; *e.g.* the hydrolysis of cane sugar already referred to, and the combination of carbon monoxide and oxygen in presence of water vapour. In heterogeneous catalysis the system consists of liquid and solid (catalyst) or gas and solid (catalyst). The decomposition of hydrogen peroxide by platinum black and the reduction of organic compounds by hydrogen in presence of colloidal platinum (Willstatter's method) or palladium (Paal's method) are examples of the former The catalysis of gas reactions by solid catalysts is illustrated by the oxidation of SO_2 to SO_3 by air (or oxygen) in presence of platinum. Such reactions as the latter are sometimes referred to as *contact catalysis.*

Many theories have been put forward to account for the phenomenon, but none have been successfully applied to all the many types of catalytic actions known. Thus many of the reactions have been explained as due to the formation of intermediate compounds with the catalyst (*see* Autoxidation). Others have been explained as due to adsorption or surface condensation at the surface of the catalyst, thus producing a highly concentrated phase. The radiation hypothesis explains catalysis as due to the activation of the reacting molecules by the absorption of energy from radiations emitted by the catalyst, or by radiations themselves (*e g.* sunlight). *See* Photocatalysis, Induced Reactions, Negative Catalysis, and Antioxidants.

Catalysis Coefficient.—The catalytic effect of strong acids on the hydrolysis of esters, etc., is greater in high concentrations or in presence of neutral salts than is to be expected by direct proportionality of velocity, v, to concentration, C. This abnormality of behaviour can be corrected by introducing a factor which is the reciprocal of the conductivity-viscosity coefficient, f_n. The ratio v/C thus corrected to vf_n/C. gives a good constant. The term catalysis coefficient has been proposed for this factor in hydrogen ion catalysis. *See* Catalysis.

Catalyst.—*See* Catalysis.

Catalyst Carriers. — Substances, generally finely divided or of porous nature, upon which catalysts are deposited, to act as a support and

to expose a large surface of the catalyst; *e.g.* metallic nickel catalyst on finely divided earths (fuller's earth), and platinum on anhydrous magnesium sulphate.

Catalyst Poisons.—*See* Anticatalysts.

Cataphoresis.—The migration of the disperse phase of suspensoids and emulsoids towards the electrodes when a potential difference is applied between these. When two electrodes are immersed in such a system the suspended particles are found to wander to them under the influence of the electric field set up. The particles of a disperse phase are electrically charged, and they migrate to the electrode of opposite charge. Most particles have a negative charge when water is the dispersion medium Ordinary fine suspensions and air bubbles show this phenomenon as well as true colloidal sols. *Cf.* Electro-osmosis.

Cathode.—The negative pole or plate of an electrolytic cell, vacuum tube, etc.

Cathode Rays.—A stream of negatively charged particles projected from the cathode of a vacuum tube. These particles are electrons.

Cathodic Reduction.—Reduction processes may be carried out at the cathode during electrolysis. Thus acetone yields isopropyl alcohol, nitric acid gives hydroxylamine, sodium bisulphite is reduced to the hydrosulphite, and so on. Electrolytes furnishing hydrogen ions will produce hydrogen at the cathode, as also will metal ions, etc., by secondary reactions with the water, acid, etc , present The hydrogen reduces any reducible substances present in the solution surrounding the cathode (the catholyte).

Cathodophoresis.—A term suggested for the migration of the disperse phase particles towards the cathode. *Cf.* Anodophoresis. *See* Cataphoresis.

Catholyte.—*See* Anolyte.

Cationic Current.—In electrolysis, that portion of the current carried by the cations. *See* Transport Numbers.

Cations.—The negative ions furnished by an electrolyte. Typical cations are the metal ions, $Na^{\cdot}$, $K^{\cdot}$, $Cu^{\cdot\cdot}$(cupric), $Fe^{\cdot\cdot}$(ferrous), $Fe^{\cdot\cdot\cdot}$(ferric), $H^{\cdot}$, $NH_4^{\cdot}$, etc. *See* Ions, and Electrolysis.

c.cs.—Cubic centimetres.

Cell Constant.—The electrical conductivity of an electrolyte is measured in a vessel termed a conductivity cell. Since specific conductivity is, by definition, for electrodes one square centimetre in area and one centimetre apart, if the cell electrodes have not these dimensions, the conductivity as measured will have to be corrected by a factor in order to reduce it to the required standard. This factor depends on the size and shape and distance apart of the electrodes, and is termed the cell constant (or sometimes the resistance capacity). If κ_1 is the specific conductivity for a given electrolyte, and κ_2 that actually measured, then $\kappa_1 = K\,\kappa_2$ or $\kappa_1/\kappa_2 = K$, where K is the cell constant. It is obtained by measuring the conductivity of a solution whose specific conductivity is known.

Centinormal.—*See* Normal Solutions.

Centre of Symmetry.—*See* Symmetry, Crystal.

Cerebrosides.—Glucosides occurring in the brain and nerve tissues of animals.

Ceryl (Radical).—The normal paraffin group, $C_{26}H_{53}$—.

Cetyl (Radical).—The normal paraffin group, $C_{16}H_{33}$—.

C.g.s. (System).—The fundamental units of the metric system; centimetre, gramme, second.

Chain Isomerism.—*See* Isomerism, Chain.

Chalcography.—A name suggested for that branch of microscopy involving the study and examination of opaque crystals and ores by reflected light.

Charles' Law.—The change in volume of all gases at constant pressure is the same for the same change in temperature. The law may be expressed thus:

$$V_t = V_0\,(1 + \alpha t^{\circ}),$$

where V_0 is the volume at 0°, V_t the volume at t° C., and α is a constant, termed the coefficient of thermal expansion. It has the value $\frac{1}{273}$. Thus for every increase in temperature of 1° C. a gas expands $\frac{1}{273}$rd of its volume at 0° C. This is also termed by some the Law of Gay-Lussac, but there is another and better-known law of Gay-Lussac. *See* Combining Volumes, Law of.

Chelate (Groups).—A term introduced by G. T. Morgan, in connection with co-ordination compounds, to denote "those caliper-like groups which function as two associated units and fasten on to the central metallic atom so as to produce heretocyclic rings." Ethylene diamine, $NH_2.CH_2.CH_2.NH_2$ is an example of such a group.

Chemical Constant.—The Clapeyron equation (*q.v.*) may be written

$$\lambda_m - RT = RT^2 \frac{d \log C}{dT},$$

where C is the concentration (since in the gas law $pv = RT$, v may be written $\frac{1}{C}$, therefore $p = RTC$. This is the substitution made in the above equation). λ_m is the molecular heat of vaporisation. The term $\lambda_m - RT$ may be written in the form

$$\lambda_0 + \alpha_0 T + \beta_0 T^2 + \gamma_0 T^3 + \ldots$$

and therefore

$$\log C = \frac{-\lambda_0}{RT} + \frac{\alpha_0}{R}\log T + \frac{\beta_0}{R}T + \frac{\gamma_0}{2R}T^2 + \ldots + i$$

where i is the integration constant.

Since, as above, $RCT = p$, therefore

$$\log p = \frac{-\lambda_0}{RT} + \frac{\alpha_0 + R}{R}\log T + \frac{\beta_0}{R}T + \frac{\beta_0}{2R}T^2 + \ldots + i + \log R.$$

The terms i and $\log R$ together form a constant, designated by C_0, and termed the *chemical constant*. It has values between 2 and 4 for a large number of substances

Chemical Dynamics.—*See* Chemical Kinetics

Chemical Equilibrium.—Many chemical reactions, particularly those in homogeneous systems, do not proceed to completion. Under given conditions of temperature, pressure, and concentration, a point is reached at which, regarded statically, the reaction comes to a stop. There is then present a certain amount of the products of the reaction, together with unchanged reactants, and these amounts will be constant so long as the conditions are not altered. The equilibrium may be regarded as due to the fact that the velocity of the forward reaction (the reaction left to right in the equation below) has been equalled by that of the back reaction (right to left), the equilibrium being therefore a dynamic one. Reactions which can proceed in both directions are termed *reversible reactions*, and when they form an equilibrium they are sometimes termed *balanced actions*. They are generally expressed by equations of the type

$$A + B + \ldots \rightleftharpoons C + D + \ldots$$

the double reversed arrows indicating that the reaction is a reversible one. Chemical equilibria are governed by certain laws. *See* Mass Action, Law of; Phase Rule; and Reaction Velocity.

Chemical Kinetics.—The quantitative study of the rate of chemical changes. This branch of physical chemistry is also termed chemical dynamics. *See* Reaction Velocity.

Chemical Statics.—The study of chemical equilibria. *See* Chemical Equilibrium; Mass Action, Law of; Reaction Velocity; and Phase Rule.

Chemiluminescence.—The emission of light as a result of chemical reaction, as distinct from the light due to high temperatures (incandescence, thermoluminescence). The phenomenon occurs in many oxidation processes, such as that of phosphorus trioxide, the reaction of hydrogen peroxide and formaldehyde, etc.; the reaction of acetylene and bromine vapour, and other so-called "cold flames."

Chemo-receptors.—This name is given to those hypothetical constituents of the cells which have a specific affinity for particular drugs, the specific action of the drugs on particular groups of cells being thereby explained.

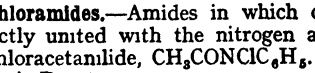
Chemo-synthesis.—A term used in biochemistry to denote the synthesis of carbohydrates and other food materials from carbon dioxide, which can be accomplished in some organisms by utilising the energy derived from the oxidation of organic or mineral compounds. This distinguishes chemo-synthesis from photo-synthesis (*q.v.*).

Chemotaxis.—The attraction exerted on living organisms by chemical compounds; *e.g.* the attraction of the male cells of ferns and mosses by an organic acid or sugar solution. In some cases repulsion, instead of attraction, takes place, and this phenomenon is referred to as negative chemotaxis. The name *chemotropy* is also employed instead of chemotaxis.

Chemo-therapy.—That branch of therapeutics which deals with the production of drugs having a destructive action on the disease-producing bacteria without affecting the tissues. Salvarsan is an example of such a drug.

Chemotropy.—*See* Chemotaxis

Chloralides.—Condensation products of chloral and certain hydroxy-acids, *e.g.* chloral and lactic acid give the chloralide



Chloramides.—Amides in which chlorine is directly united with the nitrogen atom; *e.g.* N-chloracetanilide, $CH_3CONClC_6H_5$. *See* Hofmann's Reaction.

Chloramines.—Amines in which chlorine is directly united to the nitrogen atom; *e.g.* methyldichloramine, CH_3NCl_2.

Chlorhydrins.—*See* Halohydrins.

Chlorimides.—Imides in which chlorine is directly united to the imino nitrogen. These have the general formula $R_1R_2C = N.Cl$, where

R_1 and R_2 are organic radicals; *e.g.* diphenylchlorimide $(C_6H_5)_2.C = N.Cl$.

Chlorimino-ethers.—Compounds of the general formula

$$R_1.C(OR_2) \parallel N.Cl$$

e.g. $C_6H_5C(OCH_3) \parallel N.Cl$.

See Iminoethers.

Chlorination.—*See* Halogenation.

Chlorine Index.—The volume of chlorine evolved from unit volume of dry soil by treatment with sodium hypochlorite.

Chlorion.—The chlorine ion, Cl'.

Chloroaurates.—Salts of hydrochloroauric acid, $HAuCl_4$; *e.g.* potassium chloroaurate, $KAuCl_4$. Also termed *aurichlorides*.

Chloroplasts.—Granules in plant cells containing chlorophyll and related pigments.

Chloroplatinates.—Salts of hydrochloroplatinic acid, H_2PtCl_6; *e.g.* potassium chloroplatinate, K_2PtCl_6. Also termed *platnichlorides*.

Chlorostannates.—Complex salts which may be expressed as double salts of stannic chloride and another metal chloride; *e.g.* potassium chlorostannate, $2KCl\ SnCl_4$, or K_2SnCl_6. Also termed *stannichlorides*.

Chloryl.—A term sometimes employed to denote the presence of chlorine in a compound as an electropositive element, as, *e.g.*, in the chloramines and chloramides (*q.v.*). The compound NH_2Cl, *e.g.*, is termed chlorylamine.

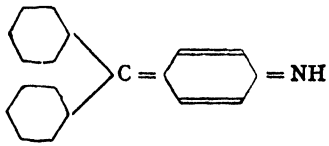
Cholagogues.—A class of purgatives which act by increasing the flow of bile; *e.g.* calomel.

Chromatic Emulsions.—Emulsions of two immiscible liquids which have the same refractive index but different dispersive powers.

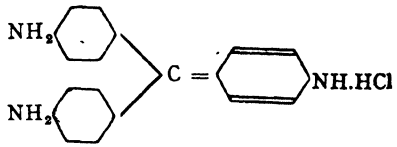
Chromic Period.—The time taken to reach the achromic point (*q.v.*) in the hydrolysis of starch by enzymes.

Chromogens.—In a dyestuff the fundamental nucleus or molecule, containing the chromophore, is termed the chromogen. The chromogen itself is not a dyestuff, but becomes one on the introduction of an auxochrome group (*q.v.*); *e.g.* azobenzene, $C_6H_5N : NC_6H_5$ is a chromogen, containing the chromophore $-N : N-$; $C_6H_5N : N\,C_6H_4.OH$ is a dyestuff.

Again, fuchsonimine



is a chromogen. It becomes a dyestuff on the entrance of two *para*-amido groups, yielding pararosaniline (hydrochloride)



See Chromophore (Groups).

Chromogens (of Urine).—Colourless compounds which are present in urine and which give, on oxidation, coloured substances, such as urobilin, indigo, urorosein, etc.

Chromoisomerism.—A type of isomerism in which the isomers exist in differently coloured modifications, *e.g.* nitrophenol methyl ether exists in both colourless and coloured modifications. The following formulæ have been ascribed to these isomers:—

$C_6H_4{<}^{OCH_3}_{NO_2}$ Colourless. $\qquad C_6H_4{<}^{O}_{NO.OCH_3}$ Coloured.

The metallic salts of violuric acid exist in a variety of coloured forms; *e.g.* the silver salt is white, green, brown, or pink, according to circumstances. The potassium salt exists in both blue and red modifications, and so on. The existence of a salt in two coloured forms is termed *dichroism*. If several such isomers exist the phenomenon is termed *polychromism*. The name *chromo ropy* (or *chromotropism*) is used to distinguish variations in colour in one salt. The term *variochromism* is sometimes employed to express the existence of two or more distinct coloured modifications of a salt. Many theories have been put forward to explain the existence of these chromoisomers, but none are entirely satisfactory. *Cf.* Halochromy. *See* Isomerism, and Valency.

Chromolipoids.—Red, orange, and yellow pigments allied to the fats, found in plants and animals. They are extracted by the usual solvents for fats. Also termed *lipochromes*.

Chromophore (Groups).—Certain atomic groupings which are responsible for the colour

of chromogens and dyestuffs. Characteristic chromophores are the azo group, — N : N —, and the benzoquinonoid ring, . *See* Chromogens.

Chromoplasts.—Yellow, orange, or red granules in the cells of plants. Their colour is due to the presence of xanthophyll or carotin. *Cf.* Chloroplasts.

Chromoproteins.—A group of conjugated proteins which are strongly coloured; *e.g.* hæmoglobin.

Chromopseudomerism.—Chromoisomerism (*q.v.*).

Chromotropy (Chromotropism).—*See* Chromoisomerism.

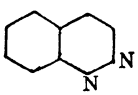
Cinnamal (Radical).—The group $C_6H_5CH : CH\,CH =$.
Also termed *cinnamylidene.*

Cinnamoyl (Radical).—The group $C_6H_5CH : CH\,CO-$.
The acid radical of cinnamic acid.

Cinnamyl (Radical).—The group $C_6H_5CH : CH\,CH_2-$.

Cinnamylidene.—*See* Cinnamal (Radical).

Cinnolines.—Derivatives of cinnoline,



Cis- (form).—*See* Isomerism, Cis-Trans.

Cis-Trans Isomerism.—*See* Isomerism, Cis-Trans.

Claisen Reaction.—The condensation between aldehydes and ketones or other aldehydes in presence of dilute caustic soda. The first stage of the reaction is an aldol condensation (*q.v.*), but in many cases the second stage (giving an unsaturated compound) is reached at once; *e.g.* benzaldehyde and acetone give benzalacetone, $C_6H_5CH : CHCOCH_3$, and dibenzalacetone, $C_6H_5CH : CHCOCH : CHC_6H_5$. Similarly benzaldehyde and acetaldehyde give cinnamic aldehyde, $C_6H_5CH : CH.CHO$.

Clapeyron's Equation.—An expression connecting vapour pressure, temperature, and latent heat of vaporisation, viz.:

$$\frac{dp}{dT} = \frac{\lambda}{T(v_2 - v_1)},$$

where p is the vapour pressure, T the absolute temperature, λ the latent heat of vaporisation, and v_1 and v_2 the specific volumes of liquid and vapour respectively. If v_1 is very small it may be neglected, and applying the gas law $pv_2 = RT$, the equation becomes

$$\frac{d \log p}{dT} = \frac{\lambda}{RT^2};$$

or

$$\lambda = RT^2 \frac{d \log p}{dT}$$

See Chemical Constant

Clausius Equation.—See Equations of State.

Cleavage (Crystal).—The splitting of crystal structures in certain directions and in certain planes.

Cleavage (Fats).—A term sometimes employed to denote the "splitting" of fats; *i.e.* the separation of the acid radicals from glycerides; *e.g.* by saponification (*q.v.*).

Clinorhombic.—*See* Monoclinic.

Clino-rhomboidal.—*See* Triclinic.

Clotting Ferments.—A class of enzyme which produces coagulation or clotting; *e.g.* thrombose, which clots blood; rennet, which clots milk, etc.

Coagulation.—A name given to several types of precipitation phenomena, in which a disperse phase is separated from the dispersion medium; *e.g.* the precipitation of certain colloids, such as proteins, by heat; the precipitation of suspensoid sols, such as colloidal gold or aluminium hydroxide, by electrolytes, etc.

Cobaltammines.—*See* Ammines.

Co-enzymes.—Substances required by certain enzymes as a condition of their activity; *e.g.* phosphates must be present with the zymase of yeast in order to ferment sugar. Also termed *co-ferments.*

Coeroxenes.—Compounds whose molecules contain an anthracene (or anthraquinone) nucleus and a xanthene (or xanthone) nucleus fused together.

Coexistence of Reactions, Principle of.—In concurrent reactions, each reaction proceeds independently of the others. *See* Wegscheider's Principle.

Co-ferments.—*See* Co-enzymes.

Cohobation.—The return of certain portions of distillate to the still for redistillation. Cohobation is resorted to chiefly when the distillate contains valuable compounds which are difficult to separate from the main distillate owing to solubility or emulsification; *e.g.* in the steam distillation of essential oils.

Collidines.—The trimethyl pyridines, $(CH_3)_3\,C_5H_2N$.

Colligative Properties.—Properties which depend on the number of atoms or molecules

present as distinct from their nature; *e.g.* osmotic pressure, and lowering of vapour pressure. *Cf.* Additive Properties, and Constitutive Properties.

Colloidal Electrolytes.—Colloidal solutions which conduct the electric current, *i.e.* show the properties of both colloids and true electrolytes; *e.g.* soap solutions. *See* Micellæ.

Colloidal State.—A large number of substances can be made to exist in a fine state of division. If present in a liquid medium, all gradations from coarse suspensions (solids) or emulsions (liquids) to true solution are attainable. Certain characteristic properties are associated with these highly disperse systems. With an ordinary suspension or emulsion the particles are visible under the microscope and have diameters of the order of 10^{-3} cms. When the size of the particles is of the order 10^{-6} cms., they are no longer visible in the microscope, but their presence may be observed in the ultramicroscope (*q.v.*). Particles of this size possess properties somewhat distinct from those of fine suspensions or emulsions, though no sharp line of demarcation can be drawn. For instance, the particles do not diffuse (or only very slowly) through a parchment or collodion membrane. (Substances in true solution diffuse more or less readily.) Their molecular weights are usually extremely high, showing that they are molecular aggregates. They show no osmotic pressure. They reflect and polarise a beam of white light (Tyndall effect). They show very rapid Brownian movement (*q v.*). They are electrically charged and undergo cataphoresis (*q.v.*). Many of these disperse systems are very stable, the particles showing no tendency to settle out. Substances which exhibit these properties are said to be in the colloidal state. Graham first gave the name *colloid* to those substances which, when in "solution" or suspension in water, did not diffuse through a parchment membrane. Those that did diffuse he termed *crystalloids*.

Graham's colloids were amorphous substances which could not be obtained in a crystalline state (or only with difficulty), such as gelatin, glue, agar, silicic acid, and so on. All substances of this nature readily form the disperse systems above referred to. The distinction between colloids and crystalloids as separate classes of substances has to some extent disappeared, since it has been found possible to prepare many substances in both the colloidal and crystalloidal states. The term colloid is preferably given to a state of matter rather than to any particular substances.

A system of colloidal particles suspended in a medium is termed a *disperse system*. The medium is termed a *dispersion medium*, and the terms *suspensoid* and *emulsoid* are employed to denote the colloidal particles of solid and liquid respectively. The two are known collectively as *dispersoids*, which may refer to either. *See* Sols, Gels, and Dialysis.

Colloid Mill.—A machine for producing colloidal suspensions or emulsions (suspensoids or emulsoids) by rapid mechanical disintegration. The substance is suspended in a liquid dispersion medium, such as water, alcohol, oils, etc. The coarse suspension or emulsion is then subjected to violent agitation by means of rapidly rotating beaters, the speed being about 2,000–3,000 revolutions per minute. There are several types of colloid mill. The best known is that designed by Plauson, and known as the "Plauson Mill."

Colloids.—*See* Colloidal State.

Colorimeter.—An apparatus for measuring the depth or intensity, and comparing the colour or shade, of coloured substances, generally in solution. Comparisons may be made with standard solutions, combinations of coloured glasses, coloured discs, or other standards. Quantitative measurements can be made in this way in the case of coloured substances which are difficult to estimate by the usual analytical methods.

Colorimetry.—The estimation or comparison of depth and shade of colour in coloured substances. *See* Colorimeter.

Combining Volumes, Law of.—When chemical combination takes place between gases, the volume of the gaseous products bears a simple ratio to that of the reacting gases. The law is also known as Gay-Lussac's Law of Combining (or Gaseous) Volumes.

Combining Weight.—*See* Equivalent Weight.

Combustion.—In a general sense the word combustion denotes a chemical reaction which is attended with considerable evolution of heat and, frequently, emission of light. Combustion reactions entail the decomposition of the combusting substance by combination with another element or compound. Common usage has restricted the term to combination with oxygen (*i.e.* oxidation reactions), in which the reactions are more or less strongly exothermic. All cases of burning, for example, are combustions. Such reactions as the burning of hydrogen in

chlorine may be, and sometimes are, classed as combustions. Oxidations which are slow, or take place at low temperatures, are not usually classed as combustions. The development of heat, and frequently of light, is generally understood, explosions accompanied by oxidation representing the other extreme. *See* Heat of Combustion.

Combustion (Analysis).—A method of ultimate analysis of organic compounds for the estimation of carbon, hydrogen (and oxygen by difference), and nitrogen. The analysis is carried out by heating a known weight of the substance in a long narrow tube heated by a furnace, a stream of air or oxygen being passed through the tube. Carbon is oxidised to carbon dioxide, which is absorbed in caustic potash or soda-lime; hydrogen is oxidised to water, which is collected in a calcium chloride tube. Nitrogen is evolved as such and is measured by volume in a nitrometer. *See* Dennstedt's method and Dumas' method.

Commuting Radical.—A name sometimes given to those organic radicals which confer ionogenic properties on atoms attached to them; *e.g.* triphenylmethyl, $(C_6H_5)_3C\sim\sim\sim$, and trimethylsulphonium, $(CH_3)_3S\sim\sim\sim$.

Co-molecule. — In Langmuir's theory of atomic structure a co-molecule is a group of atoms held together by pairs of electrons shared by adjacent atoms.

Complex Ions.—*See* Ions.

Complex Salts. — *See* Molecular Compounds.

"Complex" Theory (of Colloids).—The theory that a necessary condition for the formation of a stable sol of a substance is that the substance must be associated with small quantities of other substances in an adsorption complex; *e.g.* a stable silver sol always contains some adsorbed AgOH or AgCl; ferric hydroxide sol contains traces of HCl, and so on.

Components.—*See* Phase Rule.

Composite Reactions.—Chemical reactions involving more than one chemical change. *See* Simultaneous Reactions.

Compounds.—Substances whose molecules consist of the atoms of two or more elements in chemical combination. Carbon holds a unique position among the elements in virtue of the power of its atoms to combine with one another, giving rise to many thousands of compounds, the so-called carbon compounds or organic compounds. The compounds of the other elements are classed as inorganic or mineral compounds. *See* Molecules, Molecular Compounds, and Constant Proportions, Law of.

Concentration Cell.—An electrical cell consisting of two electrodes of the same metal immersed in a solution of the same electrolyte, but at two different concentrations. The electrode potential of metal|solution depends upon the concentration of the metal ions in the solution; *e.g.* zinc in 0·1N.$ZnSO_4$ gives an electrode potential of 0·551 volt. Zinc in N.$ZnSO_4$ gives a potential of 0·493 volt. Consequently, if these two electrodes be combined to give a cell, the electromotive force of the cell will be the difference between these two potentials, viz. 0·058 volt. Other types of concentration cell are known, but all operate on the same principle. Cells of this kind are conveniently represented thus:

$$\begin{array}{ccccc} - & & & & + \\ \text{Metal} & \left|\begin{array}{c}\text{weaker}\\ \text{solution}\end{array}\right. & & \left|\begin{array}{c}\text{stronger}\\ \text{solution}\end{array}\right. & \text{Metal} \end{array}$$

$$\text{Direction of current in cell} \longrightarrow$$

The above-described cell is represented as

$$\text{Zn} \left|\begin{array}{c}0{\cdot}1\text{N}\\ ZnSO_4\end{array}\right. \left|\begin{array}{c}\text{N}\\ ZnSO_4\end{array}\right. \text{Zn}$$

See Electrode Potential, and Gas Cells.

Concurrent Reactions.—Reactions in which the original reacting substance or substances give rise simultaneously to two or more reaction products. Such reactions may be represented thus:

$$(..+\text{F}+)\,\text{E} \leftarrow \text{A}\,(+\text{B}+...) \rightarrow \text{C}\,(+\text{D}+..)$$

or, more simply,

$$\text{A} \begin{cases} \nearrow \text{B} \\ \searrow \text{C} \end{cases}$$

e g the nitration of benzoic acid gives rise to ortho-, meta-, and para- nitrobenzoic acids simultaneously. Also termed *side reactions*. *See* Simultaneous Reactions.

Condensation (Reactions). — Reactions in which two or more molecules, or parts of the same molecule, combine, with or without elimination of constituent atoms (in the form of molecules). The term is largely, and somewhat loosely, used in organic chemistry, so much so that it has come to be confined almost solely to those reactions in which union is effected between carbon atoms. If two or more separate molecules take part in the reaction, it is termed an external condensation. If the union is between two atoms in the same molecule it is termed internal condensation. Condensation covers a large number of synthetic

organic reactions. *See* Aldol, and Benzoin, Condensations; Cyclisation; the Wurtz-Fittig, Claisen, Perkin, and Hoesch Reactions. *See also* Endo-condensation, and Exo-condensation.

Condensed Rings.—*See* Fused Rings.

Condensed System.—A system in which there is no vapour phase; *i.e.* liquid-liquid and liquid-solid systems.

Condensing Agents.—Substances which assist in bringing about condensation reactions; *e.g.* sodium ethylate in the acetoacetic ester condensations; caustic soda in the Claisen reaction; metallic copper and copper salts in anthraquinone condensations, etc. *See* references under Condensation (Reactions).

Condition Equation.—*See* Equations of State.

Conductivity (Electrical): (1) *Specific Conductivity.*—The specific resistance of an electrolyte is the resistance in ohms of a centimetre cube of the electrolyte. The reciprocal of this quantity is termed the specific conductivity. It is therefore the conductivity of a centimetre cube of the electrolyte. If the specific resistance is one ohm, the specific conductivity is one reciprocal ohm, or mho. This is the unit of specific conductivity. By Ohm's Law the specific conductivity is the current in ampères of a centimetre cube of the electrolyte when the potential difference of one volt is applied across two opposite faces of the cube. Specific conductivity is usually designated by κ; *e.g.* for 0·1N acetic acid $\kappa = 0{\cdot}000471$ at 18° C.

(2) *Equivalent Conductivity.*—The conductivity of a solution which contains one gram-equivalent of solute, when placed between electrodes one centimetre apart. If v is the volume in litres containing one gram-equivalent, then the equivalent conductivity is given by $\kappa \times 1000v$. This quantity is usually designated by Λ or λ. If C is the concentration in gram-equivalents then

$$\Lambda \text{ (or } \lambda) = \frac{1000\kappa}{C} \text{ mhos.}$$

It is assumed that at infinite dilution (*i.e.* when v is very large) the dissociation of the electrolyte is complete. The equivalent conductivity at infinite dilution is represented by Λ_∞ or λ_∞; that at volume v by Λ_v or λ_v.

(3) *Molecular Conductivity.*—The conductivity of a solution containing one gram-molecule of solute, when placed between electrodes one centimetre apart. It is represented by μ. It is given by the expression

$$\mu = 1000\kappa.v, \text{ or } \frac{1000\kappa}{C},$$

analogous to that for equivalent conductivity (above). μ_v and μ_∞ are the symbols for molecular conductivity at dilution v litres, and at infinite dilution respectively. Also termed *molar* conductivity.

Conjugated Double Bonds.—If two double bonds are separated by a single bond, as, *e.g.*, in

$$-C=C-C=C-$$

they are said to be conjugated.

Butadiene, $CH_2=CH-CH=CH_2$, and muconic acid $HOOC.CH=CH-CH=CH.COOH$, are examples of compounds containing conjugated double bonds. The bonds may be between atoms other than carbon, such as carbon and oxygen, as in the 1, 2 diketones; *e.g.* benzil,

$$C_6H_5-C(=O)-C(=O)-C_6H_5$$

A system may contain three or more double bonds in conjugation, thus:

$$-C=C-C=C-C=C-$$

A particular type of this arrangement is

$$C=C-C=C$$
$$\quad\quad\quad\quad |$$
$$\quad\quad\quad\quad C=C$$

as in dibenzal propionic acid,

$$C_6H_5CH=C-CH=CH.C_6H_5$$
$$\quad\quad\quad\quad\quad\quad |$$
$$\quad\quad\quad\quad\quad\quad HOC=O$$

Such a system is said to be *cross-conjugated*, and this arrangement of double bonds is termed *crossed double bonds*.

Conjugated Proteins.—Compounds of proteins with other substances, the protein being generally easily split off by hydrolysis; *e.g.* hæmoglobin, which is a condensation product of the protein globin, with hæmatin.

Conjugated Systems.—*See* Conjugated Double Bonds

Conjugate Solutions.—In a system of two liquids which are partially miscible, each liquid phase will be a solution of the one liquid in the other. There will be definite equilibrium concentrations at each temperature, and under equilibrium conditions the two solutions are said to be *conjugate*.

Consecutive Reactions.—A class of simultaneous reactions of the type

$$A \rightarrow B \rightarrow C$$

The initial reactant (or reactants) A, give rise to the final product (or products) C, through an intermediate product (or products), B. Two reactions are therefore proceeding simultaneously, viz. $A \rightarrow B$, and $B \rightarrow C$; *e.g.* the

hydrolysis of succinic ester by alkali, one molecule of alcohol being first split off, followed by the hydrolysis of the other. *See* Simultaneous Reactions.

Conservation of Energy, Law of.—*See* Thermodynamics, First Law of.

Conservation of Mass, Conservation of Matter, Law of.—*See* Indestructibility of Matter, Law of.

Consolute.—If two liquids (pure liquids or solutions) dissolve in each other in all proportions (*i.e.* are completely miscible) they are said to be consolute. The term may also be applied to substances which form solid solutions in all proportions.

Constant Boiling Mixtures.—*See* Azeotropic Mixtures.

Constant Proportions, Law of.—A chemical compound always contains the same elements combined together in the same proportions by weight.

Constitutional Formulæ. — *See* Formulæ, Chemical.

Constitutive Properties.—Properties of compounds which are determined chiefly by the manner in which the atoms are arranged in the molecule (*i e.* on the molecular *structure*), and not on their number or nature ; *e g.* absorption spectra.

Contact Catalysis.—*See* Catalysis.

Contact Potential.—*See* Electrode Potential.

Contra-valencies.—A term introduced by Abegg in connection with his theory that every element possesses a maximum valency of 8, made up of positive and negative components. The two valencies of opposite polarity are termed *normal valencies* and *contra-valencies*, the normal valencies corresponding with the usually accepted valencies of the elements ; *e.g.* sodium has a normal valency of + 1, and contra-valency −7 ; chlorine has normal valency −1, and contra-valency + 7 ; nitrogen, normal valency −3, and contra-valency + 5, etc.

Convergence Temperature.—In the determination of molecular weights by the freezing-point method, the temperature of the solution under examination will depend upon (1) the temperature of the surrounding cooling medium (*i.e.* the cooling or freezing bath) ; (2) the conduction of heat from outside through exposed parts of the apparatus (such as the thermometer), and (3) the heat given out by the solidification of the solvent (*i.e.* the latent heat of fusion). If no freezing takes place, then the temperature of the solution will depend upon (1) and (2). The final temperature reached, at which freezing takes place, is termed the convergence temperature and is usually below the true freezing point. In making a determination, supercooling may take place, the temperature falls to the convergence temperature, the solvent then begins to crystallise out and the temperature rises slightly.

Coolidge Tube.—A special type of X-ray vacuum tube, very highly exhausted. The cathode is an electrically heated tungsten spiral which provides the cathode rays (electrons). An anticathode of tungsten is provided.

Co-ordination.—Werner, in his theory of valency, introduced the conception of two kinds of valency, viz. *principal* (*primary* or *normal*) *valency*, and *auxiliary* (*secondary*, *partial* or *residual*) *valency*. The first kind of valency is sufficient to explain the existence of ordinary normal compounds ; the second is introduced to explain the nature of the combination in addition or molecular compounds. The formation of these complex compounds is due to the functioning of these latter valencies, and the complex molecules are said to be co-ordinated. This conception is known as the theory or doctrine of co-ordination. The formulæ given under Ammines are examples of co-ordination compounds. *See* following, and Formulæ (Chemical).

Co-ordination Number.—A term used by Werner, in his co-ordination theory of valency. It denotes the maximum number of atoms, molecular groups, or radicals which can be directly attached to an atom which acts as a central atom. It is therefore the sum of the primary and secondary valencies of the atom. For most atoms the co-ordination number is six. In some cases it is four or eight. That for carbon, *e.g.*, is four. *See* Co-ordination, and Valency.

Copper Number (Copper Value, Copper Index).—The amount of copper obtained by reduction of a copper solution (*e g.* Fehling's solution) by reducing carbohydrates (reducing sugars, cellulosic compounds, etc.). Cuprous oxide is obtained which is estimated in various ways. A valuable method of estimation of certain carbohydrates and their derivatives, and a test of the purity of others (*e g.* cotton) which do not reduce copper solutions.

Corresponding States.—The pressure exerted by a substance may be expressed as a fraction of the critical pressure of that substance.

Similarly, the temperature may be expressed as a fraction of the critical temperature, and the volume as a fraction of the critical volume. If two substances have pressures which are the same fraction of their respective critical pressures, they are said to be at *corresponding pressures*. Similarly, they are at *corresponding temperatures* and *corresponding volumes* when their temperatures and volumes are the same fraction of their respective critical temperatures and volumes. The following equation, known as the *Reduced Equation of State*, shows the relationship between these quantities:

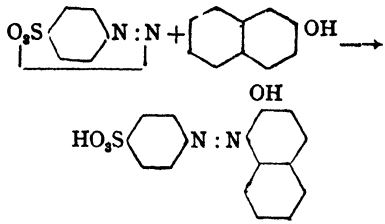
$$\left(\pi + \frac{3}{\varphi^2}\right)(3\varphi - 1) = 8\theta,$$

where π, θ, and φ are the fractions of the critical pressure, temperature, and volume respectively. It will be seen from this equation that if any two of the three variables are fixed the third is also fixed. Substances having all three of these fractions the same are said to be in *corresponding states*. *See* Equations of State.

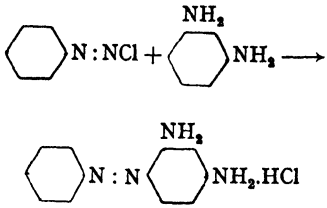
Coulometer.—An instrument for measuring quantity of electricity (coulombs) in electrochemical processes. The quantity of electricity passing through the circuit is usually measured by the deposition of a metal at the cathode, the amount deposited (according to Faraday's Law) being proportional to the quantity of electricity which has passed. This amount is measured by the increase in weight of the cathode. Also termed a voltameter (silver voltameter, copper voltameter, etc.).

Coupled Reactions.—Reactions in which the energy given out by one reaction is utilised to enable another reaction to take place; *e.g.* in the spontaneous oxidation of phosphorus, benzaldehyde, etc, two oxidation products are formed simultaneously in equivalent proportions—a lower oxide (phosphorus oxide, benzoic acid) and a higher oxide (ozone, benzaldehyde peroxide). The energy given out in the formation of the phosphorus oxide or benzoic acid enables the ozone or other peroxide to be formed.

Coupling.—The condensation of a diazotised amine with an amine or phenol. The condensation takes place between a nitrogen atom of the diazo group and a nuclear carbon atom of the amine or phenol; *e.g.* diazotised sulphanilic acid couples with β-naphthol to give the well-known dyestuff Orange II:



Similarly, diazotised aniline couples with *m*-phenylonediamine to give the dyestuff chrysoidine:



In the benzene series the diazo group couples in the *para*- position to any OH or NH_2 group. If this position is occupied it enters the *ortho*-position. If this position is also occupied more frequently no coupling takes place, but sometimes the *para*- group is displaced by the entering diazo group. The diphenols and diamines of the benzene series only couple with diazo compounds when the two OH or NH_2 groups are in the *meta*- position, as in chrysoidine (above). In the naphthalene series, if the α- position is occupied, coupling takes place in the 4 position. If the substituent is in the β- position, coupling takes place in the α- position, as in the case of Orange II (above). *See* Azo-compounds, and Diazo Reaction.

Co-valency (Co-valence).—According to Langmuir's theory of atomic structure, co-valency is the number of pairs of electrons which an atom can share with its neighbours.

Co-volume.—*See* Equations of State.

Crenation.—The withdrawal of water from blood corpuscles by the action of concentrated salt solutions.

Cresotyl (Radical).—The group $OH.C_6H_3(CH_3).CO-$.
The radical of cresotic or cresotinic acid.

Cresylates.—Metallic salts of the cresols; *e.g.* sodium cresylate, $CH_3.C_6H_4.ONa$. *Cf.* Phenates.

Cresyl (Radical).—The group
$$OH.C_6H_3(CH_3)-.$$
From cresol.

Critical Coefficient.—The critical temperature divided by the critical pressure
$$\frac{\theta_0}{\pi_0} = \kappa.$$
κ = critical coefficient.

Critical Concentration.—*See* Critical Solution Temperature.

Critical Constants.—If a liquid is heated in a closed vessel the pressure and density of the vapour will increase, and the density of the liquid will decrease, with rise of temperature. If the heating be continued a temperature will be reached at which the liquid and vapour have the same density. At this point there is no distinction between the liquid and vapour phases, the whole system becoming one homogeneous phase. The temperature at which this takes place is termed the *critical temperature* and the pressure exerted by the system is termed the *critical pressure*. At temperatures above the critical, the vapour becomes a gas, and no pressure can now cause the formation of liquid. The volume of unit mass of substance at the critical temperature is termed the *critical volume*, and the reciprocal of this is the *critical density*; *e.g.* nitrogen has a critical temperature of −146° C., critical pressure 35 atmospheres, and critical density 0·299. Water has a critical temperature of 364° C., critical pressure 195 atmospheres, and critical density 0·208.

Critical Density.—*See* Critical Constants.

Critical Opalescence.—The cloudy or opalescent effect observed in vapours at the critical pressure, and temperatures slightly above the critical. It is due to there being points in the system at which the temperature is below the mean critical temperature, some liquefaction taking place. Also a liquid shows this opalescence or turbidity just before reaching the critical temperature.

Critical Positions.—A name sometimes applied to the fifth and sixth atoms in a normal acyclic chain of five or six carbon atoms; *e.g.* the last or end atoms in normal pentane and normal hexane. If such a carbon chain be arranged according to the space or tetrahedral model for carbon atoms, the chain will be curved, and the fifth and sixth atoms will be found to lie close to the first.

Critical Pressure.—*See* Critical Constants.

Critical Solution Temperature.—The composition of the two layers of a system composed of two partially miscible liquids varies with the temperature. On raising the temperature of such a system a point will be reached at which the composition of the two layers becomes identical; *i.e.* a homogeneous liquid phase is obtained. Above this temperature the two liquids are miscible in all proportions. This temperature is the *critical solution temperature*, and the concentration of either one of the components is termed the *critical concentration*; *e.g.* water and phenol are miscible in all proportions above 68·4° C. Below that temperature two layers are formed, one being a solution of phenol in water and the other water in phenol At 68·4° C. the concentration of phenol is 36·1 %.

Critical Temperature.—*See* Critical Constants.

Critical Volume.—*See* Critical Constants.

Croceo—A prefix sometimes employed for the cobaltammines having the general formula $Co_2(NH_3)_8$, $(NO_2)_4$, X_2, (X_2 = two atoms of a univalent acid radical, or their equivalent), *e.g.* croceocobaltic chloride, $Co_2(NH_3)_8$, $(NO_2)_4$, Cl_2. So called on account of their yellow colour.

Crocins.—Glucosidic compounds which form the colouring matters of the saffrons.

Cross-conjugation.—*See* Conjugated Double Bonds.

Crossed Double Bonds.—*See* Conjugated Double Bonds.

Crum Brown and Gibson, Rule of.—A rule for the position of entering groups (halogens, NO_2, SO_3H, etc) in a mono-substituted benzene. If the group already present can form a compound with hydrogen which is oxidised directly to the corresponding hydroxyl compound, then the entering group will take up a *meta* position. If not, the substitution will be *ortho* or (and) *para*.

Cryohydrates.—Eutectic mixtures of a salt and ice. These mixtures are of constant composition and were at one time regarded as compounds and given the name cryohydrates. The temperature at which they separate out (quadruple point, or eutectic point) was termed the *cryohydric point*. Sodium chloride cryohydrate separates at −23° C. and contains 23·6% NaCl. Magnesium sulphate cryohydrate separates at −5° C. and contains 21·86% $MgSO_4$. A large number of these particular eutectic mixtures are known. The name *Cryosel* was also proposed for them. *See* Eutectic Mixtures, and Freezing Mixtures.

Cryohydric Point.—*See* Cryohydrates.

Cryoluminescence.—The emission of light by certain substances when suddenly cooled, as, *e.g.*, by immersion in liquid air.

Cryoscopic Method.—The freezing-point method for determining molecular weights. *See* Raoult's Law.

Cryoscopy.—The determination of molecular weights by the freezing-point method. *See* Raoult's Law.

Cryosels.—*See* Cryohydrates.

Cryptocrystalline.—A term applied to certain minerals which are intimate mixtures of amorphous and crystalline compounds; *e g.* flint and chalcedony contain both amorphous and crystalline silica (quartz) and the two are very difficult to distinguish.

Crystal Lattice.—*See* Space Lattice.

Crystallisation.—The process of producing crystals. The process consists in the solidification of a substance from a homogeneous phase; *i e.* from a state of vapour, fusion, or solution. *See* Fractional Crystallisation, and Sublimation.

Crystallography.—The branch of physical science which deals with crystal structure and formation.

Crystalloids.—A name given by Graham to those substances which dialyse readily in solution. Such substances were those which crystallised more or less readily, in contradistinction to those which did not and which were found not to dialyse. Graham called these latter colloids. The name has lost much of its original significance since it has been found possible to prepare substance in both the crystalloidal and colloidal states. *See* Colloidal State, and Dialysis.

Crystalloluminescence.—The emission of light by certain substances during crystallisation. Arsenious acid exhibits this property. *See* Triboluminescence.

Crystals.—Homogeneous solid particles whose boundary surfaces are composed of plane surfaces at definite angles to one another and arranged in a definite geometrical form. All crystal forms can be classified into thirty-two classes based on considerations of geometrical symmetry. *See* Symmetry, Crystal.

Cubic System (Crystals).—Crystals which may have as many as nine planes of symmetry and six dyad, three tetrad, and four triad axes of symmetry. Also termed *tesseral, tessural, octahedral, regular,* and *isometric.* Common salt, alum, copper, silver, gold, etc., crystallise in this system. *See* Symmetry, Crystal.

Cumal (Radical).—The group

$$p\text{-}(CH_3)_2CH.C_6H_4.CH =$$

Cumulated Double Bonds.—A pair of double bonds with one carbon atom in common, thus:

$$>C = C = C<$$

Cumyl (Radical).—The group

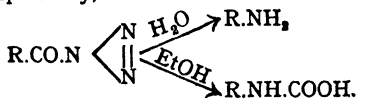
$$p\text{-}(CH_3)_2CH.C_6H_4.CH_2-$$

Cupel.—A mixture of bone ash or other refractory material moulded into the shape of a solid cylinder having a shallow depression on the upper surface. *See* following.

Cupellation.—The operation of recovering gold and silver from their lead alloys in which they have been collected during the fusion of a quantity of ore with appropriate fluxes to remove the impurities or gangue. The lead is oxidised at the temperatures of cupellation (1050–1100° C. in the case of gold) to litharge, which is absorbed by the cupel, leaving the precious metal in the form of a bead or button on the surface.

Current Density.—In electrolysis, the current strength divided by the area of the electrode. In other words, the current per unit area of electrode. It is generally expressed in ampères per square decimetre or centimetre.

Curtius' Reaction.—The action of water or alcohol on acid azides to give amines or urethanes respectively, thus:

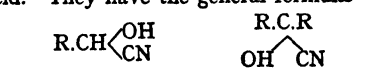


See Azides, and Urethanes.

Cutins.—The chief constituents of the protective coatings of plant organisms. On decomposition they yield compounds of the fatty series, wax alcohols, acids, cholesterol, etc. Also termed *cuto-celluloses.*

Cuto-celluloses.—*See* Cutins.

Cyanhydrins.—Addition compounds of aldehydes and ketones with hydrocyanic (prussic) acid. They have the general formulæ



aldehyde cyanhydrin — ketone cyanhydrin.

They are also sometimes termed hydrocyanides.

Cyanhydrin Synthesis.—The synthesis of hydroxyacids from aldehyde and ketone cyanhydrins by hydrolysis; *e.g.* lactic acid is synthesised from acetaldehyde, $CH_3.CHO$, by first forming the cyanhydrin $CH_3CH(OH)CN$,

and then hydrolysing the CN group to COOH, giving $CH_3CH(OH).COOH$.

Cyanide Synthesis.—The synthesis of an aliphatic acid (alcohol, etc.) from the next lower members of the homologous series; *e.g.* methyl alcohol, CH_3OH, is converted into methyl hydrogen sulphate, $CH_3.HSO_4$. KCN converts this into methyl cyanide, CH_3CN, which, on hydrolysis, yields acetic acid, CH_3COOH. This is then reduced to ethyl alcohol, C_2H_5OH. The addition of the CN group supplies the extra carbon atom. The first nine members of the aliphatic alcohols (and acids) have been prepared from methyl alcohol in this stepwise manner.

Cyano-.—A prefix denoting the presence of a CN group; *e.g.* cyanoacetic acid, $CN.CH_2COOH$, cyanobenzoic acid, $CN.C_6H_4COOH$, etc.

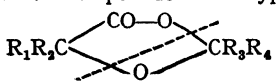
Cyanogenetic Enzymes.—Enzymes which produce hydrocyanic acid, HCN, as a result of their action on certain glucosides.

Cyclanes.—Cycloparaffins (*q.v.*).

Cyclic Compounds.—Compounds containing a closed ring structure. If all the atoms comprising the ring are the same, the compound is termed *homocyclic* or *isocyclic*; *e.g.* the benzene and cycloparaffin hydrocarbons If there is more than one kind of atom in the ring the compound is termed *heterocyclic*; *e.g.* the pyridines, quinolines, azoles, lactones, oxazines, furans, thiazines, etc. If one ring is present the compound is *monocyclic*, if two (fused or condensed) *bicyclic*, and so on. The term *polycyclic* is sometimes employed for those with more than one ring. *See* Bicyclic Compounds, and Bridged Rings.

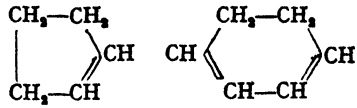
Cyclisation.—The formation of a cyclic (ring) compound from the corresponding acyclic (open chain) compound; a general term employed in organic chemistry to denote ring closure.

Cycloacetals.—Compounds of the type



where R_1, R_2, R_3, R_4, are alkyl or aryl groups (CH_3, C_2H_5, C_6H_5, etc.) or hydrogen. They are produced by the action of mixed organometallic compounds of zinc on acid chlorides of the type $R_1.O.CO.CR_2R_3COCl$. On hydrolysis the cycloacetals split as shown by the dotted line in the formula giving acids and aldehydes or ketones. *See* Blaise Reaction.

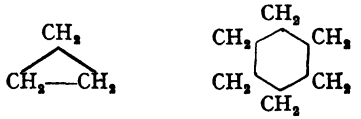
Cyclo-olefines.—Carbocyclic compounds with one or more double bonds in the ring; *e.g.*



Cyclopentene $\Delta^{1.3}$ Cyclohexadiene.

The term is only strictly applicable so long as the compound exhibits olefinic characteristics. Thus the aromatic hydrocarbons are not classed as cyclo-olefines. *See* Aromatic Compounds, and Benzenoid.

Cycloparaffins.—Saturated cyclic hydrocarbons; *e.g.*



Cyclopropane (Trimethylene) Cyclohexane (Hexamethylene).

Also termed *polymethylenes* and *cyclanes*. Those containing a ring of five or six carbon atoms are sometimes termed naphthenes. *See* Alicyclic (Compounds).

Cyclostatic.—A term sometimes applied to chromophore groups which form part of a ring; *e.g.* the ethylenic double bonds in quinonoid compounds. *Cf.* Streptostatic.

D

D-, d-.—*See* Table of Symbols, p. 157.

Dakin Solution.—*See* Carrel-Dakin Solution.

Dalton's Law (Partial Pressures).—In a mixture of gases the total pressure is the sum of the partial pressures of each of the gases present. In other words, each gas in the mixture exerts the same pressure as it would do if the other gases were absent and it alone filled the containing vessel. The law is expressed thus:

$$P = p_1 + p_2 + \text{etc.},$$

where P is the total pressure of the mixture and p_1, p_2, etc., are the partial pressures of the individual gases. The law is true only if the gases exert no chemical action on each other. Slight variations from the law are observed, due to molecular attraction. *See* Multiple Proportions, Law of.

Danysz Phenomenon.—When a diphtheria toxin is treated with its antitoxin, the neutralisation of the toxin depends on the way the antitoxin is added. An amount of antitoxin sufficient to neutralise a given quantity of toxin, if added all at once, is not nearly sufficient to

neutralise the same amount of toxin if added little by little at intervals. *Cf.* Acclimatisation.

Deamidation.—Deamination (*q.v.*).

Deaminases.—*See* Deamination.

Deamination (Deaminisation).—A general term employed to denote the elimination of an amino group from the molecule of an organic compound in which it is usually, though not necessarily, attached to carbon. The term is generally confined to those cases where the NH_2 group is replaced by hydrogen (or sometimes OH), as, *e.g.*, in the conversion of aniline, $C_6H_5NH_2$, to benzene, C_6H_6, by the diazo method. The term is not applied to general substitution of NH_2, such as, *e.g.*, by halogens, nor to such processes as the hydrolysis of acid amides. A special type of deamination is that in which the aminoacids derived from proteins lose the amino group under the action of certain enzymes, ammonia being liberated. Such enzymes are termed *deaminases*, and occur in the liver and elsewhere; *e.g.* alanine, $CH_3CH(NH_2).COOH$, yields ammonia and pyruvic aldehyde, $CH_3CO.CHO$, which then passes into pyruvic, lactic, and propionic acids successively. Again, the enzyme *guanase* converts guanine into xanthine, a C : NH group being converted into a CO group.

Decahydro-.—A prefix indicating an addition of ten hydrogen atoms; *e.g.* decahydronaphthalene, $C_{10}H_{18}$, naphthalene being $C_{10}H_8$.

Decalcification.—(1) The removal of deposited calcium salts (bone, etc.), from animal tissue. (2) The removal of calcium carbonate (oxide, etc.), from minerals which contain it; *e.g.* dolomite.

Decantation.—A simple method of separating a liquid from a solid whose density is greater than that of the liquid consists in allowing the solid to settle out to the bottom and then carefully pouring off the supernatent liquid. The liquid is said to be decanted and the operation is termed decantation.

Decarboxylation.—The removal of one or more carboxyl groups from the molecule of an organic compound; *e.g.* benzoic acid, C_6H_5COOH, when heated with lime, gives benzene, C_6H_6, and carbon dioxide CO_2. Several methods are available. *See* Carboxylases.

Decay (Radioactive), Law of.—The rate at which a radioactive substance loses its activity, or the rate of radioactive decay, is given by the expression:

$$I_t = I_0 e^{-\lambda t},$$

where I_0 is the initial activity (as measured, *e.g.*, by the rate of discharge of a gold-leaf electroscope), I_t the activity after a time t, λ a constant characteristic of the substance, and e the base of the natural logarithms.

Decinormal.—*See* Normal Solutions.

Decomposition Reaction.—A reaction in which a single compound is split up into two or more simpler compounds, or elements. Radioactive changes, destructive distillation, etc., are examples of processes involving reactions of this type, and the breaking down of complex molecules by bacteria is also included. Dissociation involves this kind of reaction. The various types of decomposition are classed as *radioactive decomposition, thermal decomposition, bacterial decomposition*, and so on.

Decomposition Potential.—*See* Decomposition Voltage.

Decomposition Voltage.—During the electrolysis of solutions of many electrolytes, polarisation occurs at the electrodes A back E.M.F. is set up and a certain voltage is required to overcome this and keep a steady current passing through the solution The minimum voltage thus required is termed the *decomposition voltage* or *decomposition potential.* This voltage varies with the concentration, the nature of the electrolyte, and the nature of the electrodes. For $N.H_2SO_4$ between platinum electrodes it is 1·67 volts; for N $ZnSO_4$, 2·35 volts; and for N.KOH, 1·67 volts with platinum electrodes in each case. *See* Discharge Potential.

Decyl (Radical).—The paraffin hydrocarbon radical $C_{10}H_{21}$—.

Definite Proportions, Law of.—Constant Proportions, Law of (*q.v.*).

Deglycerolation.—The removal of glycerin from substances containing it, free or combined; *e.g.* fats.

Degradation.—A general term employed to denote the formation of a carbon compound from a higher homologue, usually, though not always, the next higher; *e.g.* stearic acid (C_{18}) may be converted into margaric acid (C_{17}), and this into palmitic (C_{16}), and so on, through the corresponding methyl ketones. One of the best examples is that known as the degradation of the sugars (aldoses). Glucose (C_6), *e.g.*, may be degraded through the intermediate aldoses to formaldehyde (C_1). The aldoxime is first formed and converted to the nitrile by elimination of one molecule of water. The nitrile loses HCN on treatment with ammoniacal silver nitrate, giving the aldose, arabinose (C_5). This

is then treated in the same manner, giving the tetrose (C_4), and so on. The degradation may also be effected through the corresponding acids by treating their calcium salts with hydrogen peroxide and ferric iron (*e.g.* basic ferric acetate). The next lower aldehyde (aldose) is formed in each case.

Degradation of Energy, Law of.—*See* Thermodynamics, Law of.

Degree of Association.—*See* Association, Molecular.

Degree of Dissociation.—*See* Dissociation (Gaseous), and Electrolytic Dissociation.

Degrees of Freedom.—(1) *See* Phase Rule. (2) The number of independent modes of motion of a body (atom, molecule, etc.); *e g.* a body may have three degrees of freedom in translation motion, three in rotation motion (the motions being measured with respect to the three space co-ordinates), and so on. This conception of degrees of freedom is employed in molecular physics.

Dehydration.—In general, the elimination of all water from a substance, whether hygroscopic water (moisture) or water of constitution (water of crystallisation), is termed dehydration. The term is perhaps more frequently used to denote the removal of water of crystallisation, an anhydrous substance being thus obtained The dehydration of wet crystals of, *e g*, oxalic acid, copper sulphate, etc., would remove all the water leaving the anhydrous compounds $C_2H_2O_4$, $CuSO_4$, etc. The term drying or desiccation would only cover the removal of extraneous or hygroscopic water. The term dehydration has also long been employed to denote the removal of the elements of water from a single molecule of an organic compound; *e.g.* the conversion of amides to nitriles, ethyl alcohol to ethylene, etc., the usual dehydrating agents, such as sulphuric acid, phosphorus pentoxide, etc., being employed for these essentially chemical reactions, which are, perhaps, better classed as dehydration reactions.

Dehydration Reactions.—*See* Dehydration.

Dehydrogenation.—The direct removal of hydrogen from an (organic) compound. The term is restricted to the elimination of hydrogen from single molecules and does not apply to condensation reactions with elimination of hydrogen; *e.g.* tetrahydronaphthalene (tetralin) to naphthalene, hexahydrobenzene to benzene, ethyl alcohol to acetaldehyde, and so on. Dehydrogenation may be accomplished by heating in presence of certain catalysts, by boiling with sulphur, etc.

Deliquescence.—Certain compounds when exposed to the atmosphere take up water (moisture) and themselves become moist or wet, eventually forming solutions. This phenomenon is termed deliquescence and is exhibited by all compounds which combine readily with water to form hydrates. A small amount of concentrated solution is first formed. If the vapour pressure of this solution is less than the pressure of the water vapour in the atmosphere—generally about 7–10 mm.—more water will condense and the process will continue until the vapour pressure of the solution so formed is equal to that of the water in the atmosphere. Calcium chloride and sulphuric acid are common examples of deliquescent compounds. They are largely used as drying agents (or desiccants) on this account. In the case of salt hydrates these have a definite vapour pressure at a definite temperature, and if this pressure is less than that of the water in the atmosphere, water will condense on them until the vapour pressure equilibrium is reached; *e.g.* ferric chloride hexahydrate, $FeCl_3.6H_2O$, has a vapour pressure of 6 mm. at ordinary temperatures, and as this is less than the pressure of atmospheric water it deliquesces. *Cf.* Efflorescence.

Delta (Δ, δ), Position, etc.—*See* Table of Symbols, p. 157.

Delta-rays (δ-rays).—Radiations emitted by a substance which is subjected to a stream of α-rays. The δ-rays are produced by electrons with a relatively slow velocity.

Denaturation.—The change produced in albumins and globulins by various agencies as a result of which these colloids acquire the properties of suspensoids and can be coagulated (or precipitated) by salts according to the usual valency law for inorganic suspensoids.

Dendro-chemistry.—The chemistry of wood and its products; *e.g.* paper pulp, turpentine, tannins, and distillation products.

Denitration.—The removal of nitric acid from mixtures containing it, such as, *e.g.*, the waste acids from nitration processes which usually consist of sulphuric and nitric acids.

Denitrification.—The removal of nitrogen present as nitrogen compounds; *e.g.* from soils, sewage, etc.

Dennstedt's Method (Combustion).—This method of combustion consists in conducting the vapour of the substance mixed with oxygen over heated platinum in the form of platinised

asbestos or quartz. The substance is heated in a combustion tube containing the platinum, the method of conducting the analysis being otherwise similar to the ordinary combustion method. *See* Combustion (Analysis).

Depolarisation (electrical).—The removal of polarisation in an electrical or electrolytic cell. The agent which accomplishes this result is termed a *depolariser*. Thus an oxidising agent will react with the hydrogen liberated at the cathode and so prevent the polarisation which would otherwise be set up.

Depolarisation (light).—On examining polarised light after passage through suspensions of certain solids it is found that the light is no longer polarised. This *depolarisation* is probably due to multiple reflection from the surface of the particles and to the rays being differently polarised by doubly-refracting particles; 0·005 grams per litre of calcium carbonate may be detected by this method.

Depolarisers.—*See* Depolarisation (electrical).

Depolymerisation.—The breaking down of the molecules of complex compounds (polymers) into two or more simpler molecules of the same kind, viz. the kind from which the original polymer was formed; *e.g.* $N_2O_4 \rightarrow 2NO_2$. *See* Polymerism.

Deposition Pressure.—The pressure which tends to drive ions out of solution and deposit them in the atomic (or molecular) state; in other words, the osmotic pressure of the ions. *See* Electrolytic Solution Pressure.

Depsides.—Compounds formed by the condensation of two molecules of a phenolic acid. The condensation takes place between the phenolic hydroxyl of one molecule and the carboxyl group of the other. Hydroxybenzoic acid gives the simple depside

$$HO.C_6H_4.CO.O\,C_6H_4.COOH.$$

Gallic acid (3 : 4 : 5, trihydroxybenzoic acid) yields the important depside digallic acid, $C_6H_2(OH)_2.CO.O.C_6H_2(OH)_2.COOH$, which is a constituent of many tannins.

Desiccants.—*See* Desiccator.

Desiccator.—An apparatus for drying a substance or keeping it in a dry state. In its commonest form it consists of a thick-walled glass vessel having a bottom compartment which contains a powerfully hygroscopic or deliquescent substance (*i.e.* a *desiccant*), such as calcium chloride or concentrated sulphuric acid. It is closed with a glass cover-lid fitting tightly by means of a ground glass flange joint. The cover may be provided with a stopper or bung carrying a glass tube and tap, by means of which the desiccator is connected to a vacuum pump and evacuated. This type of vessel is termed a *vacuum desiccator*.

Desmotropism (Desmotropy).—*See* Isomerism, Dynamic.

Desorption.—The removal of a substance from a state of sorption; *e.g.* the liberation of hydrogen from platinum or palladium in which it has been adsorbed.

Desoxy-.—A prefix used to denote the removal of one atom of oxygen from the molecule of an organic compound; *e.g.* benzoin $C_6H_5.CHOH.CO.C_6H_5$, and desoxybenzoin $C_6H_5CH_2COC_6H_5$. The prefix *de-oxy* is also sometimes used.

Desprez-Trouton Rule.—*See* Trouton's Rule.

Destructive Distillation.—A process in which a substance is subjected to strong heating out of contact with air. It thereby undergoes thermal decomposition, yielding products some or all of which are volatile at the temperature employed and which distil over. There is usually a residue of solid matter left in the heating vessel (retort), gases and vapours passing over, the latter being condensed to give the distillate. The best known examples of the process are the distillation of coal, wood, and shale.

Desyl- (Radical).—The group

$$C_6H_5.CH.CO.C_6H_5,$$
$$|$$

a radical of desoxybenzoin. *See* Desoxy.

Desylene- (Radical).—The group

$$C_6H_5.C.CO.C_6H_5;$$
$$\|$$

e.g. desyleneacetic acid,

$$C_6H_5.C(:CH.COOH).CO.C_6H_5.$$

Detonation Wave.—*See* Explosion Wave.

Detoxicating Action.—That action of a reagent by which it destroys the toxins produced by bacteria.

Deuteroproteoses.—*See* Proteoses.

Deville's "Hot and Cold" Tube.—An apparatus for obtaining the products of certain gaseous reactions which take place at high temperatures. A central tube, through which passes a rapid stream of cold water, is surrounded by another tube and the whole is placed in a furnace. The gas reaction takes place in the annular space between the two tubes. The products of the reaction are suddenly chilled by contact with the inner cold tube and are swept out of the apparatus before any back reactions can take place. It is thus possible to examine the

products at room temperatures. Thus hydrogen peroxide may be formed from oxygen and water vapour at 2000° C. and obtained before any decomposition into oxygen and water can take place.

Devitrification.—The crystallisation of glass and other amorphous vitreous materials which are in reality supercooled liquids.

Dewar Flask.—A double-walled glass vessel, the space between the walls being evacuated. In some cases the walls are silvered to prevent loss of heat by radiation. These vessels constitute the so-called *vacuum flasks* (*thermos flasks*). They are employed for the storage and transport of very volatile liquids such as liquid air, since they prevent access of heat to the contents, the vacuum space surrounding the inner wall acting as a heat insulator.

Dew Point.—The temperature at which a vapour becomes saturated and begins to deposit liquid particles.

Dew Point Method.—A method for determining vapour pressures. The liquid is placed in a vessel provided with a stopper. Through the stopper is inserted a polished silver tube containing ether or other volatile liquid. The vessel is placed in a thermostat. Air is blown through the ether, lowering the temperature, until dew deposits on the surface of the silver tube. The temperature of the tube is read. At the dew point the dew is in equilibrium with its vapour, which must also be in equilibrium with the liquid in the bottom of the vessel. The vapour pressure of water at the dew point obtained is found in standard tables This pressure is therefore the vapour pressure of the liquid at the thermostat temperature.

Dextrins.—Compounds formed from starches by hydrolysis or heating. They are intermediate between the starch and its final hydrolysis product (sugars). They are gummy substances which are strongly dextrorotatory, hence their name. Erythrodextrin $(C_{12}H_{20}O_{10})_8$, and maltodextrin (achroodextrin) $(C_{12}H_{20}O_{10})_2$ are obtained from ordinary starch.

Dextrogyrate.—Dextrorotatory. *See* Optical Activity.

Dextrorotatory.—*See* Optical Activity.

Di-.—A prefix signifying *two* or *double*. Thus dichlorides, MCl_2; dioxides, MO_2 (where M is an atom of an electropositive element). Also dimethyl, diphenyl, diacetyl, diamino, etc. The prefix *bi-* is also frequently used as in bicyclic, bitertiary, etc.

Di-acetylenes.—Compounds containing two triple bonds or acetylenic linkages; *e.g.* $CH:C.CH_2CH_2C:CH$.

Diacid (Bases).—*See* Bases.

Diactinic.—A substance which transmits photochemically active rays (actinic rays) is said to be diactinic. *See* Photochemical Activity.

-dial.—*See* Geneva Nomenclature.

Dialysate.—*See* Dialysis.

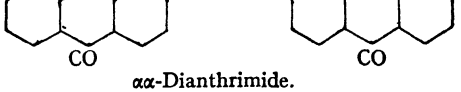
Dialyser.—*See* Dialysis.

Dialysis.—The process by which a colloidal solution is freed from crystalloids by placing it in a vessel surrounded by a solvent. The crystalloids diffuse through the parchment membrane whilst the colloids remain behind. The crystalloid solution so obtained is sometimes termed the *dialysate*. Other membranes or septa may be employed, such as, *e.g.*, pig's bladder, but they are all of colloidal nature. The relative rates of diffusion of the crystalloids vary considerably; HCl, *e.g.*, diffuses seven times as fast as cane sugar under the same conditions. By surrounding an aqueous solution of gelatin and common salt contained in a parchment bag by pure water the salt diffuses out into the water and the gelatin remains in the bag. The apparatus in which this process is carried out is called a *dialyser*. *See* Colloidal State, and Osmosis.

Diamagnetic Salt.—A salt of a diamagnetic metal; *i.e.* of a metal whose magnetic permeability is less than unity. Sodium, tin, copper, silver, gold, zinc, mercury, and lead are examples of diamagnetic elements, which also include hydrogen, chlorine, and bromine. The ions of these elements are sometimes referred to as diamagnetic ions. *Cf.* Paramagnetic Salts.

Diammines.—Ammines (*q.v.*) containing two molecules of ammonia, NH_3.

Dianthrimides.—αα-, ββ, or αβ-dianthraquinonylamines:—



αα-Dianthrimide.

Diaphoretics.—Drugs which induce perspiration; sudorifics.

Diastatic Activity (Diastatic Power).—The activity of diastase in the hydrolysis of starch.

Diatomic.—*See* Atomicity.

Diazines.—*See* Azines.

Diazoamino- (Compounds).—Compounds of the type $R_1.N:N.NH.R_2$, where R_1, R_2 are

alkyl or aryl radicals; *e.g.* diazoaminobenzene, $C_6H_5N : N.NH.C_6H_5$.

Diazoates.—Salts of *diazoic acids, e.g.* sodium benzenediazoate, $C_6H_5N : NO.ONa$. The acid $C_6H_5N : NO.OH$ is isomeric with the corresponding phenylnitramine, $C_6H_5NH.NO_2$.

Diazo- (Compounds).—In general, compounds containing the diazo- group. Compounds of the type $R_1N : N.R_2$, where R_1 and R_2 are organic radicals, are classed as azo- compounds (*q.v.*), the prefix diazo- usually denoting the presence of the group $-N : N.X$, where X is a negative radical such as Cl, Br, NO_3, SO_4H, OH, OCH_3, etc. When the configuration $>N : N$ or $-NX . N$ (Blomstrand formula) is assigned, the term *diazonium* is employed by analogy with ammonium, as, *e.g.*, in the case of the diazonium salts The prefix diazo- is thus mainly reserved for those compounds, other than the azo- compounds, which contain the group $-N : N-$, such as the aliphatic diazo- compounds, diazomethane CH_2N_2, diazoacetic ester $N_2CH.COOC_2H_5$, the diazoates (*q v.*), etc. Compounds containing two diazo groups have the prefix *bisdiazo-* or *disdiazo-*.

Diazo-Esters.—See Diazo- (Compounds).

Diazo- (Group).—*See* Diazo Reaction

Diazo-hydrazo- (Compounds).—Compounds containing the group $-N : N.NH\,NH-$ (sometimes termed the *buzyl* group). They may be considered as derivatives of the hypothetical *buzylene* $NH : N.NH\,NH_2$.

Diazoic Acids.—*See* Diazoates

Diazoimido- (Compounds).—Azoimides (*q v.*).

Diazoles.—*See* Azoles.

Diazonium Compounds.—Compounds of the type $RNX : N$, where R is an organic radical such as phenyl, naphthyl, etc. If X is an acid radical such as Cl, Br, NO_3, HSO_4, etc., the compound is termed a *diazonium salt, e.g.* $C_6H_5N_2Cl$, benzenediazonium chloride If X is OH, the compound is termed a *diazonium hydroxide*; *e.g.* $C_6H_5N_2OH$, benzenediazonium hydroxide. *See* Diazo- (Compounds).

Diazonium Halides.—Diazonium compounds of the formula $R.NX : N$, where X is a halogen, *e.g.* benzenediazonium bromide, $C_6H_5NBr : N$.

Diazonium Perhalides.—Compounds formed by addition of halogens to a diazonium halide; *e.g.* diazonium bromide adds a molecule of bromine to give the perbromide $C_6H_5NBr.NBr_2$.

Diazonium Salts.—*See* Diazonium Compounds.

Diazo Reaction.—The conversion of primary amines into diazonium salts. The reaction is generally carried out by means of nitrous acid (sodium nitrite and HCl or H_2SO_4, or amyl nitrite). The reaction may be represented by the general equation

$$R.NH_2.HX + HNO_2 \rightarrow R.NX : N + 2H_2O.$$

The process is termed *diazotisation* and the group $>N : N$ or $-N : N-$, the *diazo group*.

Diazotates.—Salts of benzene (etc.) diazohydroxide, $C_6H_5N : N.OH$ (benzene diazotic acid); *e.g.* potassium benzenediazotate $C_6H_5N : N\,OK$. The hydroxide, which is only known in solution, forms, under certain conditions, a diazooxide or anhydride $(C_6H_5N_2)_2.O$, which can be isolated.

Diazotisation.—*See* Diazo Reaction.

Dibasic.—*See* Basicity.

Dicarbazyls.—Compounds formed by condensation of two molecules of carbazole with elimination of two atoms of hydrogen. Analagous to the diphenyls (*q v*)

Dicarboxylic Acids.—*See* Carboxylic Acids.

Dichroins.—A name sometimes given to compounds exhibiting dichroism. *See* Chromoisomerism.

Dichroism.—*See* Chromoisomerism.

Dicyano-.—*See* Dinitriles.

Dicyclo-.—A prefix used before the names of certain bicyclic compounds; more frequently *bicyclo-*. *See* Bicyclic Compounds.

Dieckmann Reaction.—The synthesis of cyclic compounds by the condensation of oxalic (etc) esters with esters of certain aliphatic mono- and di-carboxylic acids, etc., using sodium or sodium ethoxide as condensing agent; *e.g.* glutaric and oxalic esters give a diketo-cyclopentane dicarboxylic ester, thus:

$$\begin{array}{lll} C_2H_5OOC.CH_2 & C_2H_5OOC & C_2H_5OOC.CH—CO \\ \quad\dot{C}H_2+ & \quad\quad | \rightarrow & \quad\quad\dot{C}H_2 \quad | \\ C_2H_5OOC\,\dot{C}H_2 & C_2H_5OOC & C_2H_5OOC.CH—CO \end{array}$$

The reaction has been extended by Komppa and is sometimes known as the *Dieckmann-Komppa Reaction*. A large number of cycloparaffin derivatives have been prepared in this way.

Dieckmann-Komppa Reaction.—*See* Dieckmann Reaction.

Dielectric Constant.—The electrostatic force exerted on each other by two electrically charged bodies varies with the medium separating them. If the force is *k* in vacuo (or air), in another medium it will be D.*k*, or if *e* is the

charge on each, d the distance between them, and F the force, then

$$F = \frac{e^2}{D.d^2},$$

where D is the dielectric constant. For most gases D has the value (about) unity. Liquids have values differing over a wide range; *e.g.* for benzene D = 2·3; aniline, 7·3; pyridine, 20; methyl alcohol, 32; water, 80; hydrocyanic acid, 95; all at 18° C. Insulating or non-conducting media of this kind are termed *dielectrics*. Liquids with high dielectric constant have strong dissociating power; *i.e.* they give good conducting solutions when electrolytes are dissolved in them. This is known as the *Nernst-Thomson Rule*, but there are many exceptions.

Dielectrics.—*See* Dielectric Constant.

-diene.—*See* Geneva Nomenclature

-dienone.—*See* Geneva Nomenclature.

Dieterici, Equation of.—*See* Equations of State.

Diffusion.—If two gases of different densities and which do not react with one another be mixed, it will be found that after a time the gaseous mixture is homogeneous; *i.e.* all parts have the same composition. The heavier gas is not found in greater quantity at the bottom and the lighter one at the top Again, if two miscible liquids of different densities and which do not react chemically be mixed, the two will form a single homogeneous liquid phase. Further, if two solutions of a salt at different concentrations, or solutions of two different salts which do not react, be mixed, the same phenomenon is observed and a homogeneous solution is obtained. In each of these cases there is an intimate co-mingling, despite differences in density, and this intermixing goes on till all parts of the system are alike in composition. The phenomenon is termed diffusion and is due to the translatory motions of the molecules of the constituents. *See* Diffusion Constant, Osmosis, Fick's Law, and Graham's Law.

Diffusion Coefficient.—*See* Fick's Law.

Diffusion Constant.—(1) For the diffusion of substances whose particles or molecules are relatively large, *e.g.* dispersoids, the diffusion constant is the quantity D given by the expression

$$D = \frac{R.T}{N.6\pi\rho r},$$

where R is the gas constant, T the absolute temperature, N the Avogadro number, ρ the viscosity of the liquid medium, and r the radius of the diffusing molecule. D may be defined as the amount of substance which diffuses per second across a unit cube when there is unit difference of concentration between the two opposite faces of the cube. (2) *See* Fick's Law.

Diffusion Potential.—If two solutions of the same electrolyte at different ionic concentrations, or of different electrolytes at the same or different concentrations, are brought into contact, there will arise a difference of potential between them owing to the ions in the stronger solution diffusing into the weaker solution. The positive and negative ions will not diffuse at the same rate owing to their having different ionic mobilities (velocities). Hence the stronger solution will lose one kind of ion more rapidly than it will the other. Consequently it will take on a charge opposite in sign to that of the ion which has diffused out of it at the greater rate. Further, the weaker solution will have an electrical charge owing to the excess of the faster ion which has diffused into it. At the boundary between the solutions there is set up a difference of potential. For two solutions of the same binary electrolyte giving only univalent ions this potential difference is given by the expression

$$E = \frac{u - v}{u + v} \cdot \frac{R\,T}{F} ln \frac{c_1}{c_2},$$

where u and v are the ionic mobilities of the two ions, R the gas constant, T the absolute temperature, F = one faraday (96,540 coulombs), c_1 the ionic concentration of the stronger solution and c_2 that of the weaker (ln = natural logarithms).

Diffusivity.—*See* Fick's Law.

Dihydric.—*See* Alcohols

Dihydro-.—A prefix denoting the addition of two hydrogen atoms; *e.g.* benzene, C_6H_6 → dihydrobenzene, C_6H_8.

Dihydroxy-.—A prefix denoting two hydroxyl (OH) groups.

Diketones.—*See* Ketones.

Dilatometer.—An apparatus for measuring changes in volume, such as those occurring at the transition point (*q.v.*). The commonest form consists of a bulb and capillary tube in one piece. The substance is introduced into the bulb, which is then sealed up and filled with an indifferent liquid to a convenient height in the capillary. The bulb and its contents are then subjected to gradual changes in temperature, the change in volume of the liquid being measured by the rise or fall of the level in the

capillary. A sudden change in volume of the substance under investigation is indicated by an appreciable change in the level of liquid in the capillary.

Dilution Law.—According to the theory of electrolytic dissociation, a binary electrolyte AB will dissociate in solution into the two ions $A^{\bullet}$ and B'. The solution will therefore contain the ions $A^{\bullet}$ and B' and the undissociated molecules AB. There will be an equilibrium between these which is dependent on the temperature. Applying the law of mass action the equilibrium may be expressed thus:

$$\frac{[A^{\bullet}] \times [B']}{[AB]} = K,$$

where K is the dissociation constant. If α is the degree of dissociation there will be $1 - \alpha$ undissociated molecules and 2α ions. If c is the concentration (*e.g.* in gram-molecules per litre), then the concentration of the undissociated molecules is $(1 - \alpha)c$ and that of the ions αc. If v is the dilution (in litres) the concentrations may be written $\frac{1 - \alpha}{v}$ and $\frac{\alpha}{v}$ respectively. Substituting these values in the above equation,

$$\frac{(\alpha c)^2}{(1 - \alpha)c} \text{ or } \frac{\left(\frac{\alpha}{v}\right)^2}{\left(\frac{1 - \alpha}{v}\right)} = K;$$

that is,

$$\frac{\alpha^2}{(1 - \alpha)v} = K.$$

This expression is known as the Dilution Law, or Ostwald's Dilution Law. It is only true for weak electrolytes, such as acetic acid, ammonia, etc. Since the degree of dissociation is measured by $\frac{\lambda_v}{\lambda_\infty}$ or $\frac{\mu_v}{\mu_\infty}$ (*see* Conductivity, Electrical), the equation may be written

$$\frac{\mu^2{}_v}{\mu_\infty(\mu_\infty - \mu_v)v} = K.$$

If α is very small, as in the case of very weak electrolytes, the above two equations approximate to the simplified expressions

$$\frac{\alpha^2}{v} \text{ or } \frac{\mu^2{}_v}{\mu^2{}_\infty} = K.$$

See Electrolytic Dissociation, and Mass Action, Law of.

Dimeric.—*See* Polymerisation.

Dimeride.—*See* Polymerisation.

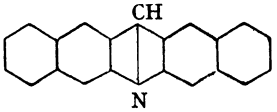
Di-meta.—*See* Meta.

Dimethyleneimines.—Derivatives of dimethyleneimine $\begin{matrix} CH_2 \\ | \\ CH_2 \end{matrix} > NH$

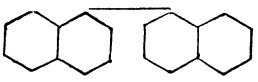
Dimorphism.—*See* Dimorphous.

Dimorphous.—A substance which exists in two crystalline forms belonging to two different crystal systems is said to be dimorphous or to exhibit *dimorphism*. Many elements and compounds are dimorphous; *e.g.* potassium sulphate (monoclinic and rhombic), sulphur (monoclinic and rhombic), tin (rhombic and tetragonal), etc. *See* Isodimorphous.

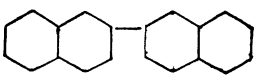
Dinaphthacridines.—Acridine with two fused or condensed benzene rings; *e.g.*



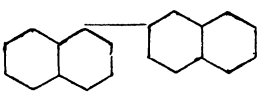
Dinaphthyls.—The three ($\alpha\alpha$, $\beta\beta$, and $\alpha\beta$) dinaphthyls and their derivatives:



$\alpha\alpha$-Dinaphthyl.

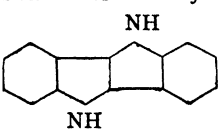


$\beta\beta$-Dinaphthyl.



$\alpha\beta$-Dinaphthyl.

Dindyls.—Derivatives of dindyl



Dineric Surface.—The curves (isothermals) for a ternary system are represented on a triangular diagram. In order to represent the effects of change of temperature a solid figure is employed, viz. a right prism with the triangle as the base. The state of the system is now represented by a surface, termed the dineric surface. *See* Ternary Systems.

Dinitriles.—This name is largely used to denote a class of compounds obtained by the condensation of two molecules of a nitrile $R.CH_2.CN$, or of one molecule of $R.CH_2CN$ with

one of R'.CN, where R and R' are hydrocarbon radicals and R may be hydrogen. They exist in two tautomeric forms:

$$R'.C.CH_2CN \quad \rightleftharpoons \quad R'.C = CH.CN$$
$$\| \qquad\qquad\qquad |$$
$$NH \qquad\qquad\qquad NH_2$$

Compounds containing two nitrile (CN) groups are usually designated by the prefix *dicyano-*. Thus $C_6H_5(CN)_2$ is not generally referred to as phthalic dinitrile but as dicyanobenzene.

Dinitro-.—*See* Nitro (Group).

-dioic Acid.—*See* Geneva Nomenclature.

-diol.—*See* Geneva Nomenclature.

-dialal.—*See* Geneva Nomenclature.

-dioldioic Acid.—*See* Geneva Nomenclature.

Diolefines.—*See* Olefines.

-diolic Acid.—*See* Geneva Nomenclature.

-dione.—*See* Geneva Nomenclature.

Di-ortho-.—*See* Ortho-.

Dioxy-.—Dihydroxy (*q v.*).

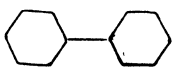
Dioximes.—*See* Oximes.

Diozonides.—*See* Ozonides.

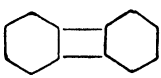
Dipeptides.—*See* Polypeptides.

Diphenols.—*See* Phenols.

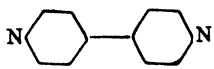
Diphenyls.—Derivatives of diphenyl (biphenyl):



Diphenylenes.—Derivatives of diphenylene (biphenylene):

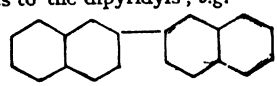


Dipyridyls.—Compounds obtained by the condensation of two molecules of pyridine. Analogous to the diphenyls; *e.g.*



γγ-Dipyridyl.

Diquinolyls.—Compounds obtained by the condensation of two molecules of quinoline. Analogous to the dipyridyls; *e.g.*



Disaccharoses (Disaccharides).—*See* Sugars.

Disazo-.—*See* Azo (Compounds).

Discharge Potential.—The decomposition voltage (*q.v.*) of a salt depends on the potentials of the two electrodes; *i.e.* the potentials, anode | anolyte and cathode | catholyte. These potentials are known as the discharge potentials of the anion and cation respectively. The sum of the two is the decomposition voltage of the salt (acid, or base). The discharge potential of zinc is −0·493, that of copper + 0·606, and silver + 1·048 volts, each with respect to normal solutions, normality being in gram-ions per litre. The chlorine ion has a discharge potential of + 1·694, the nitrate ion (NO'_3) + 1·75, the sulphate ion (SO''_4) + 1·9, and the hydroxyl ion (in bases) + 1·16 volts, all with respect to normal solutions of ions.

Discontinuous Spectrum.—*See under* Spectrum.

Dis-diazo-.—*See* Diazo- (Compounds).

Disglomeration.—A term applied to the crumbling of a reguline metal, such as lead, copper, or tin, into a powder composed of single crystallites, when the metal is attacked by suitable reagents; *e.g.* tin in contact with a solution of $SnCl_2$ containing H_2SnO_3 yields a coarse powder of white tetragonal tin.

Disperscope.—An apparatus used in conjunction with a microscope for the examination of disperse systems.

Disperse Phase.—In a disperse system there are two phases, viz. the dispersoid and the dispersion medium. The former constitutes the *disperse phase* and the latter the *continuous phase*.

Disperse Systems.—*See* Colloidal State.

Dispersion.—The formation of a disperse system. *See* Colloidal State.

Dispersion (Light).—The difference in the specific refractions for the monochromatic light corresponding to the wave lengths of the blue (H_γ) and red (H_α) spectral lines of hydrogen is termed the *dispersion*. The H_β line is sometimes taken instead of the H_γ line. The dispersion is given by the expression

$$\left(\frac{n^2_\gamma - 1}{n^2_\gamma + 2} - \frac{n^2_\alpha - 1}{n^2_\alpha + 2}\right) \cdot \frac{1}{d}$$

where n_γ and n_α are the refractive indices for the γ and α hydrogen lines respectively, and d is the density. The *atomic dispersion* is this quantity multiplied by the atomic weight, and the *molecular dispersion* is similarly obtained by multiplying by the molecular weight. *Cf.* Specific Refraction, Molecular Refraction, and Rotatory Dispersion.

Dispersion Medium.—*See* Colloidal State.

Dispersivity.—The degree or extent of dispersion. Ostwald defines this as the ratio o

the absolute surface of the particle to its volume. Ordinary suspensions and emulsions show a low, and colloidal solutions a high, dispersivity. The maximum dispersivity is reached with true solution.

Dispersoids.—*See* Colloidal State.

Dissociation.—A general term employed to denote the splitting up of a molecule of a compound or element into two or more simpler molecules or atoms (or ions), in such a way that these latter will recombine to give the original molecule if the conditions under which the dissociation is produced are reversed. That is, there is an equilibrium between the compound and its dissociation products. Dissociation phenomena are conveniently classed into two categories, viz., *gaseous dissociation* and *electrolytic dissociation*. *See* these and also Mass Action, Law of.

Dissociation, Electrolytic.—*See* Electrolytic Dissociation.

Dissociation (Gaseous).—The molecules of many gases and vapours split up into two or more simpler molecules or atoms under certain conditions, generally by the action of heat (*thermal dissociation*). This type of dissociation is termed *gaseous dissociation*. The ratio of the amount (number of molecules) dissociated to the total amount (total number of molecules) originally present is termed the *degree of dissociation* and is a fractional quantity usually designated by α. If a molecule of a gas or vapour dissociates into n simpler molecules and α is the degree of dissociation, then the number of simpler (dissociated) molecules is $n\alpha$ and the number of undissociated molecules is $1 - \alpha$. The total number of molecules (originally expressed as 1) is therefore

$$1 - \alpha + n\alpha = 1 + \alpha(n - 1).$$

The dissociation reaches an equilibrium which is dependent on the temperature and pressure. Ammonium chloride, NH_4Cl, dissociates into ammonia, NH_3, and hydrochloric acid, HCl; ammonium carbamate, $NH_2.CO.NH_4$, into ammonia, $2NH_3$, and carbon dioxide, CO_2; nitrogen peroxide, N_2O_4, gives two molecules of NO_2; hydriodic acid, HI, gives hydrogen and iodine; iodine molecules dissociate into iodine atoms, and so on. The dissociation of solids which yield gaseous dissociation products (*e.g.* calcium carbonate, $CaCO_3 \rightarrow$ calcium oxide, CaO + carbon dioxide, CO_2) is generally classed as gaseous dissociation, since the solids are present in the vapour phase and the dissociation takes place in that phase. See Mass Action, Law of.

Dissociation Constant.—*See* Dilution Law, and Mass Action, Law of.

Dissociation Pressure.—If a compound dissociates yielding one or more gaseous products, the amount of the latter, and consequently its pressure, will depend on the temperature. The pressure exerted at equilibrium is termed the *dissociation pressure*; *e.g.* the dissociation pressure of calcium carbonate, where the gas phase is carbon dioxide, is 755 mm. at 910° C.

Dissolution.—The process of dissolving; *i.e.* the formation of a solution.

Distillate.—*See* Distillation.

Distillation.—The process of heating a liquid to its boiling point and conducting the vapour through a cooling apparatus (condenser) in which the vapour is condensed to liquid, and collecting the liquid (termed the *distillate*) in another vessel (the receiver). Distillation is generally employed for the separation of a more or less volatile liquid from a non-volatile or less volatile substance with which it is mixed. It thus serves as a method of purification. In general, the term distillation covers any process in which a substance or substances are heated in one vessel, all or part of them being converted into vapour, which is condensed outside the distillation vessel and collected separately. The substances being distilled may or may not undergo chemical changes during the process. There are several special types of distillation, for which see Destructive Distillation, Fractional Distillation, Steam Distillation, and Vacuum Distillation.

Distillation in Steam.—*See* Steam Distillation.

Distillation in Vacuo.—*See* Vacuum Distillation

Distribution Coefficient.—(1) *See* Distribution Law.

(2) A special case of (1) is the ratio of the solubility of a compound in fat to that in water. This ratio is of value in determining the relative rate of diffusion of certain compounds (drugs) in protoplasm. The relative diffusion rate is roughly proportional to the distribution coefficient.

Distribution Law.—If two immiscible liquids dissolve a substance, this substance will distribute itself between the two liquids in such a manner that the ratio of its concentrations in the two liquids is a constant (at constant temperature), provided that the molecular weight of the substance is the same in each solvent; *i.e.* no molecular association or electrolytic dissociation takes place. If c_1 is the

concentration in one solvent and c_2 that in the other, then

$$\frac{c_1}{c_2} = \text{constant} = K \quad \text{.....(1)}$$

This is the Distribution Law (also known as the *Partition Law*, or *Nernst's Law of Partition*, or *Distribution*). The constant K is termed the *distribution* (or *partition*) *coefficient*. The above ratio is not constant but varies with the concentration if the substance associates or dissociates in one or both solvents. If, *e g*, the substance A associates to a certain extent in one of the solvents to give the double molecule 2A, then

$$A + A \rightleftharpoons 2A;$$

and by the law of mass action

$$\frac{[A]^2}{[2A]} = k_1 \quad \text{.....(2)}$$

where k_1 is the equilibrium constant. If the molecular weight is normal in the other (second) solvent, the distribution law will apply as between it and the normal molecules in the first solvent (in which there is association, as above); *i.e*

$$\frac{[A_1]}{[A_2]} = K \quad \text{.....(3)}$$

as in equation (1). $[A_1]$ is the concentration of normal molecules in the first solvent and $[A_2]$ that of the normal molecules in the second. Equations (2) and (3) give

$$\frac{[A_1]}{\sqrt{[2A]}} = \sqrt{k_1} \times K = K_2 \quad \text{.....(4)}$$

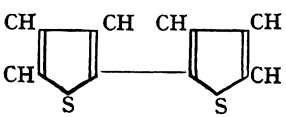
See Henry's Law for distribution between liquid and gaseous phases.

Disulpho-.—*See* Sulphonic Acids.

Diterpenes.—*See* Terpenes

Ditertiary.—*See* Bitertiary.

Dithienyls.—Compounds obtained by the condensation of two molecules of thiophene with elimination of two atoms of hydrogen. Analogous to the diphenyls, dipyridyls, etc. (*q.v.*); *e.g.*



Dithio-.—A prefix denoting a content of two sulphur atoms, as in the organic disulphides, *e g.* dithioaniline $(C_6H_4NH_2)_2S_2$; thioacids, *e g.* dithiobenzoic, C_6H_5CSSH; dithiobiuret, $NH_2CS.NH.CS.NH_2$, etc. *See under* Thio-.

Dithionates.—Salts of dithionic acid, $H_2S_2O_6$, $(HO.SO_2 - SO_2.OH)$. Also termed *hyposulphates*.

Ditolyls.—Dimethyldiphenyls $CH_3C_6H_4 - C_6H_4.CH_3$.

Diureides.—Compounds of two ureide molecules; *e g.* allontoin and murexide. *See* Ureides.

Diuretics.—Substances whose administration causes increased flow of urine.

Divalent.—*See* Valency.

Divariant.—Bivariant. *See* Phase Rule.

Dodecyl (Radical).—The paraffin hydrocarbon radical $C_{12}H_{25}$—.

Dolomitic.—A name given to minerals containing the essential constituents of dolomite, viz. calcium and magnesium carbonates.

Double Bonds.—*See* Valency, Molecules, and Formulæ.

Double Decomposition.—The interaction of two salts resulting in an exchange of anions, thus

$$M_1A + M_2B = M_1B + M_2A,$$

where M_1 and M_2 are two different elements (metals) and A and B are two different anions (acid radicals); *e g.*

$$NaCl + AgNO_3 = NaNO_3 + AgCl.$$

Double Layer.—*See* Electrical Double Layer.

Double-Oblique.—*See* Triclinic.

Double Salts.—*See* Molecular Compounds.

Draggendorf's Reagent.—Potassium iodobismuthate Used as a test for alkaloids.

Dry Distillation.—The distillation of a solid substance. If decomposition occurs the process is termed destructive distillation (*q.v.*); if not, the process is one of sublimation (*q v.*).

Dulcigenic Groups.—Groups to which the sweet taste of certain organic compounds is ascribed.

Dulong and Petit's Law.—*See* Atomic Heat.

Dumas' Method.—A method for estimating nitrogen in organic compounds. The substance is heated with copper oxide, generally in a stream of carbon dioxide. The nitrogen is partly converted into nitrogen oxides, which are reduced to nitrogen by passing over heated copper. The volume of nitrogen evolved is measured in a nitrometer.

Duplet.—According to the Lewis-Langmuir theory of atomic structure atoms combine by sharing electrons. Since these are supposed to be situated at the corners of a cube, a combination of two atoms, each sharing an electron, will be a combination by a single bond, represented by a common edge of the two cubes.

The two electrons (one from each atom) are termed a duplet.

Dyad (Axis of Symmetry).—*See* Symmetry, Crystal.

Dyads.—(1) An obsolete name for a divalent element.

(2) A name proposed by Van Laar for those tautomeric compounds in which the wandering (hydrogen) atom is attached to either of two other atoms which are directly linked together.

Dynamic Allotropy.—*See* Allotropy.

Dynamic Equilibrium.—*See* Chemical Equilibrium.

Dynamic Isomerism.—*See* Isomerism, Dynamic.

Dystetic.—A term sometimes employed to denote those mixtures or compounds which have a maximum freezing or melting point, in distinction to those which have a minimum freezing point (eutectics); *e g* ferric chloride and water in the proportions, one of $FeCl_3$ to twelve of H_2O freezes (melts) at 37° C In any other proportions within certain limits, the mixture has a lower freezing point.

E

e.—*See* Table of Symbols, p. 157.

Ebullioscopic Method.—*See* Ebullioscopy, and Raoult's Law.

Ebullioscopy.—The determination of boiling points. A special case is that of the determination of the boiling points of solutions, which is employed for the determination of molecular weights, and which is termed the boiling point or ebullioscopic method. *See* Raoult's Law.

Ecbolics.—Drugs which stimulate action of the uterus.

Ecto-enzymes.—Enzymes which act normally outside the cells which produce them.

Efflorescence.—Certain substances which contain water of constitution lose that water on exposure to the atmosphere. Many hydrates whose vapour pressures are greater than the partial pressure of the water in the atmosphere lose their water of crystallization and become anhydrous; they *effloresce*; *e g.* $Na_2CO_3.10H_2O$, whose vapour pressure at ordinary temperatures is 24 mm., that of atmospheric water being about 9 mm. *Cf.* Deliquescence.

Effusion.—The flow of gas through a small aperture. Graham's Law of diffusion (*q.v.*) applies to effusion; *i.e.* the relative rates of effusion are inversely proportional to the square roots of the densities.

Ehrlich's Diazo Reaction.—A test applied to urine. Equal volumes of diazobenzene-sulphonic acid and urine are mixed and excess of ammonia added. If a red colour is produced a pathological condition of the urine is indicated whose nature is in dispute.

Eicosi-.—A prefix meaning twenty, as, *e.g.*, in ammonium eicosichloro-enneamercuriate, $Hg_9N_2H_8Cl_{20}$.

Einhorn Tube.—An apparatus in which sugars are estimated by fermentation with yeast.

Electrical Birefringence (Double Refraction).—Many liquids become doubly refracting to light when placed in an electric field; *i.e.* they exhibit electrical birefringence. If Δ is the lag (measured in wave lengths) between the ordinary and extraordinary ray, then

$$\Delta = Kl\frac{v^2}{d^2},$$

where l is the wave length of the light in the liquid, v the voltage, and d the distance between the electric poles producing the field K is a constant known as the *Kerr Constant*, and is characteristic for the particular liquid.

Electrical Double Layer.—The layer of positive and negative charges at the interface of a metal (negative) and a solution of its ions (positive), as, *e.g.*, in the case of a metal immersed in a solution of one of its salts. *See* Electrode Potential, and Electrolytic Solution Pressure.

Electro-affinity.—*See* Electrode Potential.

Electro-analysis.—Chemical analysis by means of the electric current. Metals may be detected and estimated by electrolysis, a process in which they are deposited on the cathode. In a solution of nickel and copper salts the copper is deposited alone so long as the voltage is maintained at 1·29 volts. Similarly, a pure metal may be obtained from a crude or impure one by making the latter the anode and regulating the voltage so that the other metals present are not deposited. The term may be used to cover analytical methods involving measurement of electromotive force or of conductivity, as in the determination of hydrogen ion concentration by means of the hydrogen electrode, electrometric titration (*q.v.*), the change of conductivity at the end point of a titration, etc.

Electrochemical Equivalence.—*See* Faraday's Laws.

Electrochemical Equivalent.—*See* Faraday's Laws.

Electrochemical Series.—The elements arranged in descending order of their electro-affinities. Under given conditions any element will displace from solution any other element below it in the series. *See* Electrode Potential.

Electrochemistry.—That branch of chemistry which deals with chemical changes which bring about, or are brought about by, electrical phenomena or processes, such as the production of electromotive force and the electric current as a result of chemical reactions, and the decomposition of compounds by the electric current (electrolysis), etc. In other words, electrochemistry is the study of the relationship between electrical and chemical energies.

Electrode Potential.—When a metal is placed in contact with a solution containing ions of the metal (*e g* a solution of one of its salts), one of two processes will take place: either ions will leave the metal and go into the solution, or the reverse process will take place, ions leaving the solution and being deposited on the metal In the first case, the ions will carry positive charges into the solution, which will become positively charged, the metal becoming negatively charged to the same extent owing to the loss of the positive charges In the second case, the deposition of the ions will give a positive charge to the metal and leave the solution negatively charged. In both cases there will be a difference of potential between the metal and solution (*contact potential*) This difference is termed the electrode potential. Standard electrode potentials are usually given with respect to a normal solution of ions; *i.e.* one containing one gram-ion per litre. For ordinary temperatures (18° C) the normal potential is given by

$$E = \frac{0.058}{n} \log C,$$

where C is the ionic concentration corresponding to the electrolytic solution pressure, and n is the valency of the ion. Under these conditions the electrode potential of zinc is − 0·493 volt, iron − 0·063, lead + 0·129, hydrogen + 0·277, copper + 0·606, silver + 1·048, iodine + 0·797, and chlorine + 1·694. These values are termed *electro-affinities* since they are a measure of the force or strength with which the ions hold their charges. Thus zinc has a greater electro-affinity than iron, iron than lead, and lead than copper. Copper is greater than silver and iodine greater than chlorine. If the elements are arranged in this order there is obtained the so-called *electrochemical series.*

Electrodes.—(1) The poles or plates of an electrolytic cell. That one by which the current enters is the anode or positive pole, and that one by which it leaves is the cathode or negative pole. (2) The half-element of an electrical cell such as a concentration cell (*q.v.*). *See* Half-element, and Calomel Electrode.

Electroendosmose (Electroendosmosis).—*See* Electro-osmosis.

Electroluminescence.—The emission of light by bodies subjected to electrical discharge; *e.g.* the characteristic colours exhibited by gases in the Geissler tubes used in spectroscopic work.

Electrolysis.—The decomposition of a substance by means of an electric current. A large number of compounds suffer decomposition when an electric current is passed through them in solution The substance in solution, termed the electrolyte, is already present dissociated to a greater or less extent into ions. Under the influence of the current the ions migrate to the electrodes, the positive ions (cations) to the cathode, and the negative ions (anions) to the anode The ions give up their charges to the electrodes. The current is thus conveyed through the solution by the ions, and the products of the electrolysis only appear at the electrodes. The products so obtained depend on the nature of the substance undergoing electrolysis, the strength of the current (current density), and the nature of the electrodes. The electrical charges associated with the ions are designated ⊖ for one negative charge and ⊕ for one positive charge. The discharge of a hydrogen ion at the cathode is represented thus:

$$H^{\cdot} = H + \oplus,$$

and that of a sulphate ion at the anode thus:

$$SO_4'' = SO_4 + 2\ominus$$

See Ions, and Faraday's Laws.

Electrolysis, Laws of.—*See* Faraday's Laws.

Electrolytes.—Substances which, when present in solution, conduct the electric current. *See* Electrolysis.

Electrolytic Cell.—The apparatus in which a process of electrolysis is carried out.

Electrolytic Dissociation.—The dissociation (*q.v.*) of an electrolyte (acid, base, salt) into ions when it is dissolved in water (or other dissociating medium; *see* Dielectric Constant). The dissociation is instantaneous. The theory of electrolytic dissociation or ionisation was first put forward by Arrhenius in order to account

for the fact that certain substances (electrolytes) when dissolved in water conduct the electric current, whereas others (non-electrolytes) do not, and also to account for the abnormal osmotic pressure of the electrolytes. The conductance is due to the ions, and only those compounds which form ions will conduct the current. The amount of compound which dissociates is represented by α, which is the ratio of the number of molecules dissociated to the total number of molecules; otherwise expressed, it is the fraction of one gram-molecule which dissociates. This fraction is termed the *Degree of Dissociation*. There will be an equilibrium between the dissociated and undissociated molecules which will depend on the original amount of electrolyte dissolved (*i.e.* the dilution) and on the temperature. If α is the degree of dissociation and v the dilution in litres, then by the mass law

$$\frac{\alpha^2}{(1-\alpha)v} = K,$$

where K is the *Dissociation Constant* or *Ionisation Constant*. (*See* Dilution Law) As the volume increases the degree of dissociation also increases, and at infinite dilution the dissociation is assumed to be complete, though it is not absolutely so, some undissociated molecules always being present. A binary electrolyte AB will give rise to the two ions A' and B'; consequently there will be present a larger number of individuals than would be the case if no dissociation took place. Since ions exert osmotic pressure the abnormal osmotic pressure of such a solution is accounted for. The dissociation constant K of an acid is sometimes referred to as its *affinity constant*; *e.g.* that for acetic acid is 0·000018 at 25° C.

Electrolytic Oxidation.—*See* Anodic Oxidation.

Electrolytic Reduction.—*See* Cathodic Reduction.

Electrolytic Solution Pressure.—If a metal be immersed in pure water there will be a tendency for metal ions to pass into solution. The ions will continue to pass into solution until a definite equilibrium is established. The force which drives the ions into solution is termed the *electrolytic solution pressure*. The solution is positively charged and the metal negatively charged, and at the boundary between metal and solution there is formed an electrical double layer (*q.v.*).

Electromers.—A name proposed for molecules whose constituent atoms are considered to be bound together by electrovalencies.

Electrometric Titration.—An analytical method for the determination of acids, bases, etc., which rests upon the measurement of the concentration of hydrogen ions in the solution. This is done by measuring the potential of a hydrogen electrode immersed in the solution containing the hydrogen ions (*i.e.* a hydrogen electrode potential). During titration, such as the neutralisation of an acid by a base, the potential will gradually change until at neutralisation point there will be a sudden jump in the voltage. If the voltage readings are plotted against the c cs. of acid or alkali added, there will be a big deflection in the curve at the end point In practice the hydrogen electrode immersed in the solution to be titrated is made a half-element of a cell, the other half-element being a standard (*e g.* calomel) electrode. The e.m.f of this cell is balanced against a dry cell or other source of voltage by means of a rheostat, the e.m.f. being read off on a voltmeter. If it is desired to measure the hydrogen ion concentration of a solution, this may be obtained by means of the formula

$$\text{e.m.f.} = 0{\cdot}058 \log \frac{1}{c},$$

(if a calomel electrode is employed), c is the concentration of the hydrogen ions in gram-ions per litre. On transposing, this formula gives

$$\frac{\text{e.m.f.} - 0{\cdot}285}{0{\cdot}058} = -\log c = p_H.$$

The method is of great utility when dealing with highly coloured or turbid solutions and in other cases where the use of indicators is precluded.

Electronegative.—*See* Electropositive.

Electrons.—The negatively charged particles which, in varying numbers, form part of the atom of elements. They are all identical from whatever element they are derived. An electron has a mass of about 8×10^{-28} gms., or about $\frac{1}{1800}$ that of a hydrogen atom; its diameter is about 3×10^{-13} cms., and it carries a charge of $4{\cdot}774 \times 10^{-10}$ electrostatic units.

Electro-osmosis.—The flow of liquid towards the electrodes when an electric current is passed through the liquid, which is divided by a porous diaphragm. It is explained by the fact that a difference of potential develops at the interface between the walls of the pores in the diaphragm and the liquid in contact with them, so that when the system is subjected to

the action of an electric field, as the diaphragm is fixed, the liquid moves. The reverse aspect of the same phenomenon is seen in cataphoresis (*q.v.*), where the solid particles of the disperse phase are free to move. The terms *electro-endosmose* and *electro-endosmosis* are also employed.

Electrophoresis.—A general term for the migration of a particle (solid, liquid, or gas) suspended in a mobile medium, under the influence of a unidirectional electrical stress (field or current).

Electropositive.—Many elements have a tendency to form ions with a positive charge; *i.e.* the atoms tend to acquire one or more positive charges. Other elements show the opposite tendency, and their atoms acquire one or more negative charges. Otherwise expressed the former, termed *electropositive* elements tend to lose electrons and become positively charged; the latter, the *electronegative* elements, tend to acquire electrons and thus become negatively charged. The metals are, in general, electropositive, oxygen, the halogens, etc., being electronegative. Certain groups and radicals are also classed as electropositive or negative according as they show the above tendency or increase that of the atoms with which they are in combination. Thus, the radicals NO_3, SO_3H, etc., are electronegative as they readily acquire negative charges to give the corresponding anions. Similarly, NO_2, CO, COOH, etc., in organic compounds increase the acid nature of the molecule and are therefore electronegative. On the other hand, the amino group, NH_2, is electropositive since it tends to acquire a positive charge and to increase the basic character of the molecule of which it is a part.

Electrostriction.—The contraction in volume of a solvent when an electrolyte is dissolved in it, due to the action of the electrical field set up by the ions; or the contraction in volume which occurs when gases are placed in an electrical field.

Electrovalency.—A term employed by Langmuir in his octet theory of atomic structure to denote the number of electrons which an atom must gain or lose in order to acquire the same stable grouping of electrons that is found in the nearest related atom of one of the inert gases.

Elements.—All matter may be regarded from a purely chemical point of view as being composed or built up of atoms. There are about ninety different kinds of atoms, and any substance which is composed entirely of one kind of atom is an element. An element therefore cannot be resolved by any chemical means so far known into two or more different kinds of matter having different chemical properties. *See* Atoms, and Radio-activity. *Cf.* Isotopes.

Elutriation.—The separation of particles of powders of different densities by a process of washing and decantation whereby the lighter or smaller particles are washed away from the heavier or denser.

e/m.—*See* Table of Symbols, p. 157.

Emission Spectrum.—*See* Spectrum, Emission.

Emmenagogues.—Substances which increase the menstrual flow.

Empirical Formulæ.—*See* Formulæ (Chemical).

Emulsides.—A term used in von Weimann's classification of colloids to denote those substances which are intermediate in properties between emulsoid sols and true solutions; *e.g.* some of the products of the action of alkalis on albumin, such as protalbic and lysalbic acids, are able to diffuse through parchment, but their solutions are opalescent and they have protective properties.

Emulsifying Agents.—Substances which enable emulsions of high concentration of one liquid in another to be formed because of their action in lowering the surface tension between the liquids; *e.g.* soaps, saponins, etc.

Emulsions.—Systems in which one liquid is dispersed in another The degree of dispersion is not high, this being the feature which distinguishes emulsions from emulsoids (*q.v.*).

Emulsoids.—Colloidal solutions (sols) in which the disperse phase is a liquid. *See* Colloidal State, and Sols.

en.—*See* Formulæ (Chemical), (2).

Enamic.—*See* Enimisation.

Enimic.—*See* Enimisation.

Enimisation.—An isomerisation or intramolecular rearrangement analogous to the keto-enol isomerisation but involving an amine and imine group instead of a keto and alcohol group. It may be represented by the scheme:—

$$>C=C-NH- \rightarrow >CH-C=N-$$
$$\quad | \qquad\qquad\quad |$$
$$\text{I.} \qquad\qquad \text{II.}$$

e.g.

$$C_2H_5.CH=C(CH_3)-NH.NH-C(CH_3)=CH.C_2H_5 \rightarrow$$
$$C_2H_5.CH_2-C(CH_3)=N.N=C(CH_3)-CH_2.C_2H_5.$$

I is termed the *enamic* form, and II the *enimic* form.

Enantiomorphism.—*See* Enantiomorphs.

Enantiomorphous.—*See* Enantiomorphs.

Enantiomorphs.—The two optical isomers

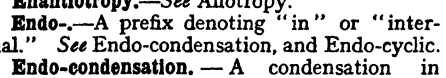
(dextro- and lævo-) of an optically active compound crystallise in two hemihedral forms which are related to one another as object to mirror image, just as in the case of the tetrahedral model of the asymmetric carbon atom. These two crystalline forms are termed enantiomorphs (enantiomorphous forms). They are also termed *optical antipodes* and *optical inverts*. *See* Optical Activity; Isomerism, Optical; and Asymmetry, Molecular.

Enantiotropic.—*See* Allotropy.

Enantiotropy.—*See* Allotropy.

Endo-.—A prefix denoting "in" or "internal." *See* Endo-condensation, and Endo-cyclic.

Endo-condensation. — A condensation in which two atoms of a ring are linked up by means of a bridge. A monocyclic compound is thus converted into a bicyclic compound; *e.g.* in the synthesis of tropane from suberone the following stage occurs:—

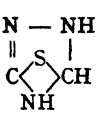


See Bridged Rings. *Cf.* Exo-condensation.

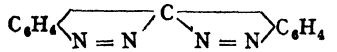
Endocrine Function.—Some glands, while able to deliver secretions by ducts, also produce other secretions which pass directly into the blood stream, just as in the endocrine glands (*q.v.*). This part of the work of such a gland is called its *endocrine function*.

Endocrine Glands.—Ductless glands. Those which pass on their secretions to the rest of the body, not by ducts, but directly into the blood stream by the veins which pass through the glands.

Endocyclic.—A term denoting "in," "part of," or "internal with respect to" a ring. The term is applied to atoms, groups, double bonds, etc., when it is desired to emphasise that these form part of a ring, and the prefix *endo-* is used for convenience in naming the compounds themselves; *e.g.* the following compound may be named *endothio*triazoline or *endoimino*thiobiazoline according to whether it is intended to emphasise that the sulphur atom is *endo* with respect to the triazole ring, or that the imino group is *endo* with respect to the thiobiazole ring:—



Again, the following compound may be named *endobisazo*diphenylmethane, indicating that the two azo groups are cyclic:—



The sulphur atom, imino group, and azo groups cited in the formulæ above are endocyclic. Similarly a double bond may be endocyclic, such as that in the triazole ring above. The first formula given above is an example of an endocyclic compound, other examples of which are furnished by the bridged ring compounds (*q.v.*). *See* Endo-condensation.

Endo-enzymes.—Enzymes which are not excreted by the cells which produce them but which act inside the cell.

Endogenous Metabolism.—That form of metabolism which yields products of constant quantity under varying diets; these products are chiefly creatinine and sulphur.

Endosmosis.—In osmosis that flow or diffusion *into* the system.

Endothermic.—If a chemical reaction takes place with absorption of heat (*i.e.* a greater amount of energy is associated with the products than with the reactants), it is said to be endothermic. Similarly any compound which is formed from its elements with absorption of heat is termed an endothermic compound; *e.g.*

$$C + S_2 = CS_2 - 19{,}000 \text{ cal.}$$

This is an endothermic reaction and carbon disulphide is an endothermic compound. *See* Hess' Law, and also under Heat of —— *Cf.* Exothermic.

End-point.—*See* Titration.

Ennea-.—A prefix meaning nine; *e.g.* enneamercuriammonium iodide, $Hg_9N_4I_6$.

Enolic Compounds.—*See* Isomerism, Keto-enol.

Enol-Keto Isomerism.—*See* Isomerism, Keto-enol.

Enols.—*See* Isomerism, Keto-enol.

Enzymes.—A class of catalysts produced by the cells of living organisms. The name was given by Kühne in 1878. Their constitutions are unknown. They generally react specifically with particular groups of substances and are named according to the group upon which they react by adding the suffix *-ase* to the class name of the group of substances. In some of the older names the suffix *-in* is used. In classifying the enzymes according to the character of the chemical reaction which they produce, such names as proteolytic and lipolytic were formerly

used for the protein-splitting and fat-splitting enzymes. The termination *-lytic* is now usually replaced by *-clastic*.

Enzymolysis (Enzymosis).—A reaction promoted or catalysed by enzymes.

Epimeric.—A name suggested for certain stereoisomeric sugars. Thus xylose and lyxose are epimeric, as are also arabinose and ribose, and mannose and glucose.

Epipolic.—Pertaining to fluorescence.

Equations (Chemical).—Provided the nature and number both of the reactants and products in a chemical reaction are known, the reaction may be expressed in the form of an equation in which the terms are represented by the formulæ of the reactants and products. In a general equation of the type

$$aA + bB = cC + dD,$$

a molecules of the substance A react with b molecules of the substance B to give c molecules of the substance C and d molecules of the substance D. Thus two molecules of hydrogen unite with one of oxygen to give two molecules of water, the equation being

$$2H_2 + O_2 = 2H_2O$$

The equation also signifies that two grams of hydrogen and thirty-two of oxygen yield thirty-six grams of water. Again, one molecule of silver nitrate reacts with one of sodium chloride to give one molecule of sodium nitrate and one of silver chloride. The equation is

$$AgNO_3 + NaCl = NaNO_3 + \underset{\downarrow}{AgCl}$$

Assuming the reaction to take place in aqueous solution, the silver chloride is completely precipitated. Precipitated products are sometimes indicated by a downward arrow, as shown. Some reactions are complex but can still be expressed as an equation; *e.g.* the action of nitric acid on copper:

$$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 4H_2O + \underset{\uparrow}{2NO}$$

The evolution of a gaseous product is sometimes indicated by an upward arrow, as shown. The sign of equality in these equations is taken to mean that (i) no other products are formed than those shown, (ii) the molecules of the substances are in the ratios given, and (iii) that the reaction is not reversible. Chemical equations which thus express exact molecular quantities are termed *stoichiometric*. In reversible reactions the sign of equality is replaced by double arrows, $\rightleftharpoons$. The exact nature and amount of the products of a reaction are not always known, particularly in organic chemistry. In such cases the sign of equality is replaced by a single arrow, $\rightarrow$. Reactions taking place in aqueous solution are frequently more conveniently expressed as reactions between ions; *e.g.* the oxidation of ferrous sulphate to ferric sulphate by potassium permanganate in presence of sulphuric acid. The chemical (stoichiometric) equation is

$$10FeSO_4 + 2KMnO_4 + 8H_2SO_4 = 5Fe_2(SO_4)_3 + 2MnSO_4 + K_2SO_4 + 8H_2O$$

The much simpler ionic equation is

$$5Fe^{\cdot\cdot} + MnO^{\prime} + 8H = 5Fe^{\cdot\cdot\cdot} + Mn^{\cdot\cdot} + 4H_2O$$

In thermochemical equations the amount of heat liberated or absorbed in a chemical reaction is shown as a factor on the right hand side of the equation, thus:—

$$2H_2 + O_2 = 2H_2O + 118 \text{ cal.}$$

This equation expresses the fact that four grams of hydrogen unite with thirty-two grams of oxygen to give thirty-six grams of water (steam), and that 118 calories of heat are liberated. In equations of this type the formulæ always represent gram-molecules.

Equations of State.—Equations or expressions by means of which the physical state of a homogeneous liquid or gaseous system may be completely defined. These equations connect the variables, concentration (or volume), temperature, and pressure for a given mass of substance

(1) *Equation of Ramsay and Young.*—

$$p = kT - c.$$

The volume is kept constant. p = pressure, T = absolute temperature, and k and c are constants depending on the volume.

(2) *Equation of Van der Waals.*—

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT.$$

p = pressure, v = volume, R = gas constant, and T = absolute temperature. a and b are constants. The term $\frac{a}{v^2}$ is a correction for the attraction or cohesion between the molecules. b is the volume occupied by the molecules as distinct from the total volume of the system. The term $v - b$ is therefore the space between the molecules. b is sometimes termed the *co-volume* or *molecular co-volume*.

(3) *Equation of Clausius.*—A modified form of Van der Waals' equation in which the mole-

cular attraction is assumed to be a function of the absolute temperature :

$$\left[p + \frac{a}{T(v+c)^2}\right](v-b) = RT.$$

The letters have the same significance as before, and c is a constant.

(4) *Equation of Dieterici.*—

$$p(v-b) = RTe^{-\frac{A}{RTv}}.$$

The letters represent the same quantities as above and A is a constant representing the work done per unit mass of gas in overcoming the attraction of the molecules. e is the base of the natural logarithms.

Equilibrium (Chemical).—*See* Chemical Equilibrium, and Mass Action, Law of.

Equilibrium Constant.—*See* Mass Action, Law of.

Equilibrium, Mobile.—*See* Mobile Equilibrium, Law of.

Equilibrium Pressure.—The pressure exerted by a gaseous system or the gaseous phase of a heterogeneous system at the equilibrium temperature. *See* Dissociation Pressure.

Equivalent Conductivity.—*See* Conductivity, Electrical.

Equivalent Weight.—That weight of an element which combines with eight parts by weight of oxygen. If an element is univalent the formula of its oxide is M_2O, if divalent MO, if tervalent M_2O_3, and so on. Consequently the equivalent weight is the atomic weight divided by the valency. When elements combine they do so in amounts which are proportional to their equivalent weights. The latter are on this account sometimes called *combining weights.*

Erythrocytes.—The red corpuscles of blood

Esterification.—*See* Esters.

Esterification Constant.—*See* Reaction Velocity

Esterification Law (Victor Meyer's).—When the two ortho positions to the carboxyl grouping in benzoic acid are occupied by CH_3, $COOH$, Br, or Cl, the acid either cannot be esterified at all or only with difficulty. The law has application only to particular conditions and is not strictly true. *See* Steric Hindrance.

Esters.—Compounds formed by replacing the hydrogen of acids by an alkyl or aryl radical. They are produced from the acid and alcohol with elimination of water, just as salts are formed from acids and bases. On this account they are sometimes termed *ethereal salts* ; *e.g.* ethyl alcohol and acetic acid give ethyl acetate (acetic ester) :—

$$C_2H_5OH + CH_3COOH \rightarrow CH_3COOC_2H_5 + H_2O$$

With hydrochloric acid ethyl chloride is formed. Esters of the halogen acids are termed *haloid* esters. If one hydrogen of a dibasic acid is replaced, an acid ester is produced; *e.g.* $HOOC.COOC_2H_5$, ethyl hydrogen oxalate. If a compound contains both an acid and alcohol group these may react to give an internal ester (lactone); *e.g.* γ-hydroxybutyric acid, $CH_2OH.CH_2.CH_2.COOH$, gives butyrolactone, $CH_2.CH_2\ CH_2.CO$. In practice acid chlorides and anhydrides are usually employed in the preparation of esters; *e.g.* phenol and benzoyl chloride give phenyl benzoate :

$$C_6H_5COCl + C_6H_5OH \rightarrow C_6H_5COOC_6H_5.$$

The process of converting an alcohol (or phenol) into an ester is termed *esterification.*

Et.—*See* Ethyl (Radical).

Ethenoid.—*See* Ethylenic Linkage.

Ethenyl (Group, Radical).—The tervalent group $CH_3.C\equiv$.

Etherates.—Complex compounds obtained by the union of certain organometallic compounds with ethers; *e.g.* magnesium amyl iodide and ethyl ether give the etherate

$$C_5H_{11}MgI.2(C_2H_5)_2O.$$

Ethereal Oxygen.—*See* Ethers.

Ethereal Salts.—*See* Esters.

Etherification.—The process of formation of ethers. The term is sometimes wrongly employed to denote esterification

Ethers.—Compounds having the general formula $R_1.O.R_2$, where R_1, R_2 are alkyl or aryl radicals. If R_1 and R_2 are the same, the ether is a *simple* one ; if they are different the ether is a *mixed* one ; *e.g.* diethyl ether (ordinary ether), $C_2H_5.O.C_2H_5$; diphenyl ether, $C_6H_5.O.C_6H_5$; phenyl-methyl ether (anisole), $C_6H_5.O.CH_3$. Ethers containing the phenoxy (etc) group, C_6H_5O-, are sometimes called phenol ethers If the oxygen (the ethereal oxygen) is combined with two atoms which are themselves combined directly or form part of a chain, an *internal* or *cyclic* ether is obtained ; *e.g.* $CH_2\ CH_2\ CH_2$ (O).

Ethinyl (Radical).—The group $CH\equiv C-$.

Ethoxides.—Compounds formed by replacing the alcoholic hydrogen atom of ethyl alcohol by a metal or positive group ; *e.g.* sodium ethoxide, $NaOC_2H_5$. Also termed *ethylates*. *Cf.* Alcoholates.

Ethoxy (Ethoxyl) (Radical).—The group $-OC_2H_5$. Often abbreviated to $-OEt$ in formulæ.

Ethylates.—*See* Ethoxides.

Ethylation.—The introduction of the ethyl group into the molecule of an organic compound; *e.g.* phenol, $C_6H_5OH \rightarrow C_6H_5OC_2H_5$, phenetole; aniline, $C_6H_5NH_2 \rightarrow C_6H_5N(C_2H_5)_2$, diethylaniline, etc.

Ethylenic Isomerism.—*See* under Isomerism, Geometrical.

Ethylenic Linkage (Double Bond).—The double bond between two carbon atoms $>C=C<$; from ethylene, $CH_2=CH_2$, the simplest compound containing the group. Also termed the *ethenoid* linkage.

Ethylidene (Radical).—The group $CH_3CH=$.

Ethyl (Radical).—The group CH_3CH_2-. Frequently abbreviated to Et in formulæ.

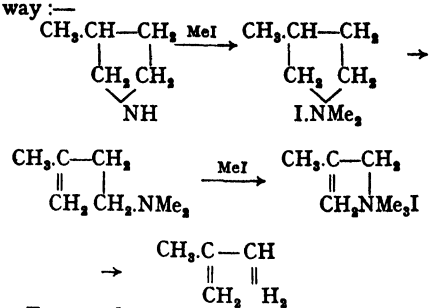
Eudiometer.—A stout, graduated glass tube closed at one end and provided at this end with two platinum poles sealed through the glass and between which an electric discharge may be passed The apparatus is used for measuring the volume changes which occur in gaseous combustion, such as, *e g.*, in the combination of hydrogen and oxygen

Eutectic Mixtures.—On cooling a solution, a temperature is ultimately reached at which the system solidifies *en masse*. The mixture of solute and solid solvent which forms at this temperature is termed a *eutectic*, or *eutectic mixture*, and the temperature at which it separates the *eutectic temperature* or *eutectic point*. At this temperature the system consists of the four phases, solid solute—solid solvent—solution—vapour. The system is therefore invariant, and any change in temperature will cause the disappearance of one of the phases. *See* Cryohydrates.

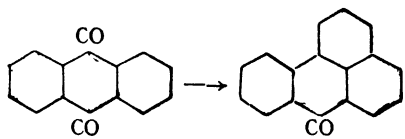
Eutectic Point.—*See* Eutectic Mixtures.

Evaporation.—A term applied to mixtures containing one or more liquid components when these latter are separated by conversion into vapour; *i.e.* by vaporisation (*q v.*).

Exhaustive Methylation.—A process in which a compound is subjected to methylation followed by another process The product so obtained is again methylated, followed by a further treatment. This process is continued until a final product is obtained which can no longer be methylated; *e.g.* isoprene is obtained from β-methylpyrrolidine in the following way:—



Exo-condensation.—If a cyclic compound undergoes a condensation in which a further ring is formed external to the first the reaction is termed an exo-condensation; *e.g.* anthraquinone to benzanthrone:—



The additional ring so formed is said to be *exocyclic* *Cf.* Endo-condensation, and Endocyclic.

Exo-cyclic.—*See* Exo-condensation. The term is also applied to double bonds, groups, etc., occurring in a side chain as distinct from the ring.

Exogenous Metabolism.—That type of metabolism in which the products vary in quantity according to the quantity of food taken. Examples of such products are urea and inorganic sulphates

Exosmosis.—In osmosis, that flow or diffusion *out of* the system.

Exothermic.—If a reaction takes place with liberation of heat (*i e.* the products contain less energy than the reactants), it is said to be exothermic. Similarly, if a compound is formed from its elements with evolution of heat it is termed an *exothermic compound*; *e.g.*

$$C + O_2 = CO_2 + 96{,}960 \text{ cal.}$$

The combustion of carbon is thus an exothermic reaction, and carbon dioxide is an exothermic compound. *See* Hess' Law, and also under Heat of ——. *Cf.* Endothermic.

Explosion Wave.—When a gaseous mixture is ignited, the zone of combustion is eventually propagated throughout the mass of gas at a constant maximum speed: an explosion or

detonation wave is developed. For hydrogen and oxygen ($2H_2 + O_2$) the explosion wave has a velocity of 2,821 metres per second; for hydrogen and chlorine ($H_2 + Cl_2$) 1,730 metres per second, and for methane and oxygen ($CH_4 + 2O_2$) 2,322 metres per second.

Exsiccation.—Desiccation; drying. *See* Desiccator.

External Compensation.—An equimolecular mixture of the dextro- and lævo- rotatory forms (optical isomers) of an optically active compound gives rise to an optically inactive product (racemate). The product is said to be inactive by external compensation; it is externally compensated. *See* Racemisation. *Cf.* Internal Compensation.

F

F.—*See* Faraday's Laws.

F°.—Temperatures Fahrenheit.

Faraday.—*See* Faraday's Laws.

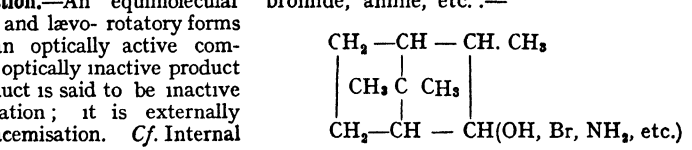
Faraday's Laws (Electrolysis).—(1) The amount of substance deposited during electrolysis is proportional to the quantity of electricity which has passed through the solution. (2) The amounts of different substances deposited by the same quantity of electricity are proportional to their equivalent weights (Law of Electrochemical Equivalence). In other words, gram-equivalent weights of all substances require the same quantity of electricity to deposit them. This quantity is 96,540 coulombs and is termed a *Faraday*, designated by the letter F. The amount of a substance deposited by one coulomb (one ampère-second) is termed its *electro-chemical equivalent* The value for silver is 0·001118 grams, that for copper 0·00032; for chlorine it is 0·000367, and for oxygen 0·0000828.

Fat-Soluble "A".—*See* Vitamins.

Fatty Acids.—The aliphatic or acyclic monocarboxylic acids are frequently referred to as the fatty acids, since many of their members are obtained by the hydrolysis of the natural fats and oils in which they are present as glycerides. By fatty acids is usually understood the saturated acids of the acetic series (formic, acetic, propionic, butyric, valeric . . . capric . . . lauric . . . myristic . . . palmitic . . . stearic . . .), but strictly speaking the term should include the unsaturated or olefinic acids of the acrylic series since members of this series also occur in fats; *e.g.* oleic acid.

Fehling's Solution.—A solution of a complex cupric salt produced by adding sodium hydroxide solution to a copper sulphate solution containing Rochelle Salt (potassium sodium tartrate). It is used for the detection and estimation of glucose and other reducing sugars which reduce it to the red insoluble cuprous oxide.

Fenchyl (Compounds).—The fenchyl alcohol, bromide, amine, etc.:—



Fenton's Reagent.—Hydrogen peroxide and ferrous sulphate. It is employed for the oxidation of alcohol groups to aldehyde or keto groups, particularly in the polyoxy compounds (carbohydrates, sugars). Thus glycerol yields glyceraldehyde; mannite gives mannose; malic acid, HOOC.CH(OH) CH_2 COOH, is oxidised to oxalacetic acid, HOOC.CO CH_2.COOH, etc.

Fermentation.—The term fermentation embraces a class of chemical changes in animal and vegetable matter brought about by the agency of certain organisms termed ferments. The name was originally given owing to the fact that frothing occurred due to the liberation of gas, as in the action of yeast on sugar, in which alcohol and carbon dioxide are produced. The different kinds of fermentation reaction are generally designated by the principal products to which they give rise; *e g.* alcoholic, lactic, butyric, etc., fermentations. The ferments were at one time considered to be living organisms (organised ferments), but it is now known that fermentation is brought about by certain substances produced by them. These substances are termed enzymes (*q v*).

Ferments.—Substances which cause fermentation. The name is now used in the same sense as enzymes (*q v.*). *See* Inorganic Ferments.

Ferrates.—Compounds of the general formula M_2FeO_4, where M is a univalent metal; *e.g.* potassium ferrate, K_2FeO_4.

Ferrites.—Compounds of ferric oxide, Fe_2O_3, with certain basic oxides; *e g.* calcium ferrite, $CaFe_2O_4$, or $CaO.Fe_2O_3$.

Fick's Law.—The amount of diffusion which takes place from one point to another in a solution is proportional to the difference in concentration between the two points. The

law is expressed by the equation

$$dS = -Da\frac{dc}{dx}dt,$$

where dS is the amount of solute diffusing across an area a in the time dt, and dc is the difference in concentration (termed the concentration gradient) between the two points which are at a distance dx apart. D is the *diffusion constant* (or *coefficient*) or *diffusivity*.

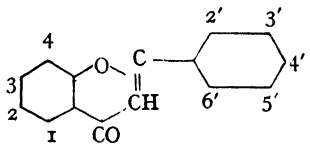
Filtration.—The process of separating a solid from a liquid, which consists in placing the mixture on a permeable or porous septum which allows the liquid to pass through but retains the solid, such as, *e.g.*, "filter" paper, cloth, asbestos, a layer of sand or charcoal, etc. The apparatus in which the process is carried out is termed a filter. If the filter is attached to a vessel and the latter evacuated the filtration is accelerated (vacuum filtration). *See* Ultra-filtration.

Fittig Reaction.—*See* Wurtz-Fittig Reaction.

Flame Spectrum.—*See under* Spectrum, Emission.

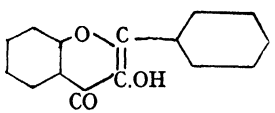
Flash Point.—That temperature at which an oil, etc., gives sufficient vapour to form a mixture with air which may be ignited. The ignition temperature or flash point is thus the minimum at which the oil vapour may be ignited.

Flavones.—A class of naturally occurring derivatives of flavone :—



They are all hydroxy or methoxy derivatives, the substitution being in the 1, 3, 3', 4', or 5' positions. They are present in various parts of plants and furnish yellow mordant dyes

Flavonols.—A class of hydroxy and methoxy derivatives of flavonol :—



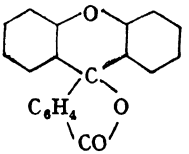
The groups are in the same positions as in the flavones, to which the flavonols are similar in occurrence and properties.

Fleitmann Test.—Arsine, AsH_3, is produced when arsenic is acted upon by hydrogen produced by the action of potassium hydroxide on zinc. This distinguishes arsenic from antimony, which does not give stibine, SbH_3, under similar conditions.

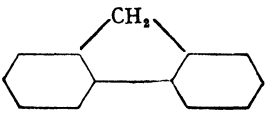
Flocculation.—The coalescence of the suspended particles of a disperse system into particles or aggregates of much larger size which settle out. The term is usually confined to suspended solids, such as suspensoid sols, fine precipitates, smokes, etc.

Flocculation Meter.—An apparatus for measuring the rate of flocculation (sedimentation, settling out) of a suspensoid; *e.g.* by measuring the rate of change of density of the disperse system.

Fluorans.—Derivatives of fluoran :—



Fluorenes.—Derivatives of fluorene :—



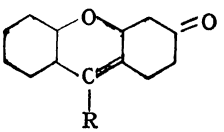
Fluorimes.—*See* Fluorones.

Fluorination.—The introduction of fluorine into the molecule of an organic compound. Only indirect methods can be applied, such as, *e.g.*, by treating other halogen compounds with silver fluoride; *e.g.* iodoform yields fluoroform $CHI_3 + 3AgF \rightarrow CHF_3 + 3AgI$, and benzoyl chloride gives benzoyl fluoride, $C_6H_5COCl + AgF \rightarrow C_6H_5COF + AgCl$. *See* Halogenation.

Fluorion.—The fluorine ion, F'.

Fluorogens.—*See* Fluorophores.

Fluorones.—Compounds having the nuclear structure



where R is a radical, generally aryl. If the quinonoid oxygen is replaced by NH the compounds are termed *fluorimes*.

Fluorophores.—Certain groupings—usually cyclic—in the molecule of a compound to which

the fluorescence is ascribed or which predisposes the molecule to fluorescence; *e.g.* the pyrone, oxazine, etc., rings. Such groupings do not produce fluorescence *per se*, the position of the grouping relative to the rest of the molecule and to other groups also being a factor. Kaufmann terms these groupings *luminophores*, applying the name *fluorogen* to certain other groups or radicals, whose presence are also necessary, just as auxochromes are required to convert chromogens into dyestuffs. *Cf* Chromophore (Groups). *See* Auxoflore, and Bathoflore (Groups).

Formazyl (Compounds).—Compounds having the general formula

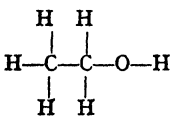
$$R{\cdot}C\begin{matrix}=N.NHC_6H_5\\ \diagdown N{:}NC_6H_5\end{matrix}$$

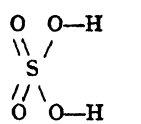
where R is an organic radical (C_6H_5, COOH, etc.) or hydrogen.

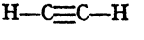
Formins.—Glycerol esters of formic acid; *e.g.* monoformin, $CH_2OH.CHOH.CH_2O.CO.H$.

Formulæ (Chemical).—The composition and constitution of the molecules of chemical compounds are symbolically represented by means of formulæ. Several types of chemical formulæ are employed according to the nature and extent of the information concerning the molecule which it is intended to convey. These are known by various names and are as follow:—

(1) *Constitutional, Graphic,* or *Structural.*—These show the manner in which the atoms are combined and indicate the nature of the linkages between the atoms, showing whether these are combined by single, double, etc, bonds to satisfy the valencies of the atoms; *e.g.*,


Ethyl Alcohol


Sulphuric Acid


Acetylene

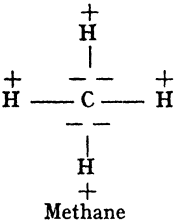
(2) *Co-ordination.*—These were first employed by Werner to represent the complex molecular compounds of the metal ammines, etc. They represent certain atoms or groups attached to a central atom in the inner or first zone by means of principal valencies. These atoms or groups are placed inside square brackets. The other atoms or groups which are in the outer zone and attached by means of auxiliary valencies are placed outside the brackets; *e.g.*

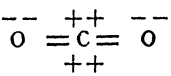
$$[Pt(NH_3)Cl_3]K,\quad [Pt(NH_3)_3Cl_3]Cl,$$

$$[Co(NH_3)_6]Cl_3,\quad [{}^{en}_{Cl}{}_2Co\ NH_3]Cl_2,$$

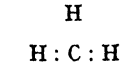
(en = ethylene diamine).

(3) *Electronic.*—These formulæ are designed to show the nature of the attachment of the atoms in accordance with the conception of the electronic theory of valency, combination being due to the gain or loss of electrons (*i.e.* exchange or sharing of electrons) between the molecules. Fry and others show the atoms as being positive or negative according as they lose or gain electrons respectively. An atom may gain or lose electrons according to the nature of the other atoms with which it is combined; *e.g.*


Methane


Carbon dioxide

In the electronic formulæ, according to the Lewis-Langmuir theory (*q.v.*), the shared electrons are represented by dots, thus:—


Methane

(4) *Empirical.*—These show the kinds of atoms present and the ratio in which they are combined; *e.g.* C_2H_6O, ethyl alcohol; CH_2O, acetic acid; CH, benzene; NaO, sodium peroxide, etc.

(5) *General.*—These formulæ are designed to give the molecular formulæ of a series or class of compounds; *e.g.* the paraffins have the general formula C_nH_{2n+2}; the olefines, C_nH_{2n}; the saturated fatty acids, $C_nH_{2n}O_2$; and so on.

(6) *Molecular.*—These are the same as the empirical, except that they give, in addition, the exact number of atoms in the molecule.

They are the most commonly employed of all the formulæ and are those by which the composition of the inorganic compounds are nearly always expressed; *e.g.* C_2H_6O, ethyl alcohol; $C_2H_4O_2$, acetic acid; C_6H_6, benzene; Na_2O_2, sodium peroxide, etc.

(7) *Rational.*—Rational formulæ are intermediate between molecular and constitutional. They give some information regarding constitution sufficient to establish relationship with some other molecule of known constitution. They indicate the presence of some atoms or groups in the molecule which have special or characteristic functions; *e.g.* $C_2H_5.OH$, ethyl alcohol; $C_6H_5.NH_2$, aniline, etc.

(8) *Space*, or *Stereometric.*—These are designed to show the spacial arrangements of the atoms. They are similar to the constitutional except that they do not represent the atoms as being all in one plane. They are frequently shown as projections of space models in which a carbon atom is represented as a regular tetrahedron. Two carbon atoms singly linked are shown by two tetrahedra joined at an apex; if they are doubly linked the tetrahedra are joined along an edge, and if trebly linked (triple bond) the tetrahedra are joined by two faces Other types of space formulæ representing projections of planes, etc, are also employed to explain stereoisomerism

Formula Weight.—The weight, expressed, *e.g.*, in grams, obtained by adding together the weights of the total number of atoms as expressed in the simple formula for the molecule of a compound. If the molecular weight is known, then this is identical with the formula weight; but in some cases a simple formula is ascribed to a compound whose molecular weight is unknown; *e.g.* starch is generally written as $(C_6H_{10}O_5)_n$. Its formula weight is $(6 \times 12) + (10 \times 1) + (5 \times 16) = 162$, but its molecular weight is unknown.

Formyl (Radical).—The group H.CO—. The radical of formic acid, H.COOH.

Fowler's Solution.—An aqueous solution of potassium arsenite.

Fractional Condensation.—The constituents of a mixture of gases or vapours may be separated by lowering the temperature or increasing the pressure (or both) until one of the constituent gases condenses to a liquid. By continuing the process other liquid fractions may be obtained. A similar process occurs in the fractionating column during fractional distillation (*q.v.*).

Fractional Crystallisation.—The separation of the constituents of a mixture of crystallisable substances by taking advantage of their different solubilities under certain conditions. By slow evaporation of the solvent the solution will become saturated with respect to one of the substances, and a portion of this will crystallise out first. Further fractions, which may be mixtures, are obtained by further evaporation. The fractions so obtained may be subjected to repeated fractional recrystallisations from fresh solutions.

Fractional Distillation.—The constituents of a liquid mixture may be separated by taking advantage of the differences in their boiling points. The mixture is distilled, and portions of the distillate collected corresponding to certain ranges of temperature. In general, the constituent with the lowest boiling point will distil first, followed by the others in order of ascending boiling points, but sharp separations are obtained only in specially favourable cases, such as when the mixture is a simple one and the differences in boiling point are considerable. It is usual to employ a fractionating column in which the vapours of the liquids with the higher boiling points are condensed and return to the still, the practicability of a separation by distillation often depending on the efficiency of this column. The process is sometimes carried out under diminished pressure. The term *fractionation* is commonly employed for fractional distillation.

Fractional Precipitation.—The separation of a mixture of substances in solution by treating the solution with some reagent which lowers the solubility of one or more of the substances present so that precipitation occurs. The reagent may precipitate the substances unaltered, or it may form a compound or compounds having a lower solubility.

Fractionation.—*See* Fractional Distillation.

Fraunhofer's Lines.—The dark lines of the continuous solar spectrum. There are a vast number of these lines, the most important of them being denoted by letters A, B, C, D, etc. These have characteristic wave lengths which are often conveniently employed as standards of reference; *e.g.* for refractive index.

Free Energy.—In the energy changes accompanying a process, such as a chemical reaction, that portion of the energy which can be obtained in the form of work (mechanical energy, electrical energy) is termed the free energy (A). There will be a simultaneous decrease (U) of

the total energy, but U and A are not identical. The energy changes may be expressed by the equation

$$U = A + Q,$$

where Q is the heat liberated or absorbed. If Q is positive then the system gives both work and heat and A is less than U. If Q is negative the system absorbs heat. In this case A is greater than U by the amount of absorbed heat which is converted into work If Q is zero, then A = U. The free energy may thus be derived entirely or only in part from the system itself, and partly or entirely from the surroundings. For an isothermal reversible process the relationship between A and U is given by the Gibbs-Helmholtz equation :—

$$A - U = T\frac{da}{dT},$$

where T is the absolute temperature, and $\frac{dA}{dT}$ is the temperature coefficient of the free energy. The affinity of a chemical reaction is measured by its free energy. *See* Affinity (Chemical), and Thermodynamics, Laws of.

Free Radicals.—Certain definite valencies are, in general, ascribed to the atoms of the elements, and in the formulæ for the compounds in which they occur these valencies are usually represented as being satisfied. Certain atomic groups or radicals are represented as being attached to a molecule by means of valencies In the compound triphenylmethyl chloride, $(C_6H_5)_3C.Cl$, the methane carbon atom is quadrivalent and the triphenylmethyl radical is represented as $(C_6H_5)_3C-$. Triphenylmethyl, however, exists as a definite compound in which the carbon atom is apparently tervalent. Such radicals which exist as compounds are termed free radicals. Diphenylhydrazyl, $(C_6H_5)_2N$, is another example. *See* following.

Free Valencies.—Certain compounds contain atoms whose full number of valencies are not satisfied by attachment to other atoms, as in the unsaturated compounds. This unsaturation is generally expressed by double or triple bonds, indicating that all the valencies are bound. It is regarded by some, however, that the valencies are not thus mutually satisfied, but are "free"; *e.g.* ethylene is usually written $CH_2 = CH_2$, but on the assumption of free valencies its formula would be $-CH_2—CH_2-$. Again, the carbon in carbon monoxide is usually regarded as bivalent, but it may be assumed to be tetravalent with two of its valencies free. In the same way the methane carbon atom in triphenylmethyl may be regarded as having a free valency, thus retaining its quadrivalent character. The conception of carbon being tervalent with respect to its attachments to other atoms and having its fourth valency free has been adopted to explain certain cases of isomerism. Free valency is not to be confused with partial or residual valency. *See* Valency.

Freezing Mixtures.—A lowering of temperature may be brought about by dissolving certain compounds in water, owing to these compounds having a negative heat of solution. The heat is absorbed from the system, whose temperature thereby falls; *e.g.* the heat of solution of crystalline calcium chloride, $CaCl_2\,6H_2O$, is −4·3 cal. If ice is added to a saturated solution of a salt in the presence of the solid salt an invariant system results, viz. ice—salt—solution —vapour. This is the system obtained by mixing ice with a salt in the case of simple freezing mixtures Such a system can only exist in equilibrium at one temperature (the quadruple or cryohydric point). One of the phases will therefore disappear until this temperature is reached; the ice melts and the latent heat of fusion of the ice is drawn from the system, whose temperature thus falls. The process will continue until the quadruple point is reached. In practice this is not always attained owing to radiation and other disturbing causes. Temperatures as low as −40 to 50° C. may be obtained with ice and single salts. With more than one salt the system becomes more complicated, but the same principles apply.

Freezing Point Method.—*See under* Raoult's Law.

Friedel-Craft Reaction.—The synthesis of organic compounds in which anhydrous aluminium chloride is used as condensing agent. The method is of wide applicability, and numerous compounds have been synthesised by its means; *e.g.* benzene and acetyl chloride give acetophenone, $C_6H_6 + ClCOCH_3 \rightarrow C_6H_5COCH_3$ benzene and methyl chloride give toluene, $C_6H_6 + ClCH_3 \rightarrow C_6H_5CH_3$; phthalic anhydride and benzene give *o*-benzoylbenzoic acid, which further condenses to anthraquinone; and so on.

Fructosans.—Anhydrosugars which yield fructose on hydrolysis; *i.e.* fructose hemicelluloses. *See* Hemicelluloses.

Fructosides.—*See* Glucosides.

Fulgenic Acids.—Compounds of the type

$$R_1R_2C = C.COOH$$
$$|$$
$$R_3R_4C = C.COOH$$

where R_1, R_3 are alkyl or aryl radicals and R_2, R_4 ditto or hydrogen. The parent unsubstituted acid is unknown. The anhydrides of these acids are termed *fulgides*.

Fulgides.—*See* Fulgenic Acids.

Fulminates.—Salts of fulminic acid, C : N.OH; *e.g.* mercury fulminate, $Hg(O.N : C)_2$.

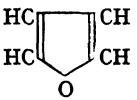
Fulvenes.—Derivatives of fulvene :—

$$\begin{array}{l} CH = CH \\ | \qquad \diagdown C = CH_2 \\ CH = CH \end{array}$$

Fumaroid.—*See under* Isomerism, Cis-trans.

Fural (Radical).—The group $C_4H_3O\,CH =$, from methyl furan. Analogous to benzal.

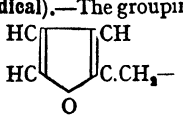
Furans.—Derivatives of furan :—



Furazans.—*See* Azoles.

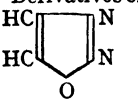
Furfur-.—A prefix denoting the presence of the furyl radical (*q.v.*).

Furfuryl (Radical).—The grouping



Analogous to benzyl.

Furodiazoles.—Derivatives of furodiazole :—



Furyl (Radical).—The group C_4H_3O-, from furan (*q.v.*). Analogous to phenyl.

Fusco-.—A prefix sometimes used for the cobaltammines, having the general formula $Co_2(NH_3)_8.(OH)_2.X_4$ (X_4 = four atoms of a univalent acid radical or their equivalent); *e.g.* fusco-cobaltic sulphate, $Co_2(NH_3)_8.(OH)_2.(SO_4)_2$. These compounds are so called on account of their brown colour.

Fused Rings.—Polycyclic (exocyclic) organic compounds in which two rings have two atoms in common, as in naphthalene, quinoline, anthracene, indole, etc., as distinct from the spiro-compounds (*q.v.*), and those in which the rings are joined by bonds between atoms in the separate rings, as in the diphenyls (*q.v.*), dipyridyls (*q.v.*), etc. Also termed *condensed rings*.

G

Galactagogues.—Drugs which increase the secretion of milk in mammals.

Galactans.—Hemicelluloses yielding galactose on hydrolysis. *See* Hemicelluloses.

Galactosides.—*See* Glucosides.

Galloyl (Radical).—The group

$$(HO)_3C_6H_2CO-.$$

The radical of gallic acid (3 : 4 : 5, trihydroxybenzoic).

Gamma (γ) Position, etc.—*See* Table of Symbols, p. 157.

Gamma-Rays (γ-Rays).—*See* Radioactivity.

Gamma- (γ-) Sugars.—A designation proposed for the more reactive forms of certain monosaccharoses, in which the greater reactivity is ascribed to the presence of a propylene oxide (or perhaps amylene oxide) ring structure. The normal forms of these sugars have the butylene oxide structure (*see* Glucosides).

Gas Cells.—Concentration cells in which the electrodes are gases. Such a cell may be obtained by employing hydrogen electrodes in contact with two solutions having different hydrogen ion concentrations; *e.g.* two HCl solutions of different strengths. The hydrogen electrodes are prepared by inserting a platinum or palladium plate in the cell solution and bubbling hydrogen into the solution in contact with the metal plate. A concentration gas cell may similarly be obtained with chlorine, the two solutions having different concentrations of chlorine ion; *e.g.* N KCl and 0.1N.KCl. *See* Concentration Cells, Electrometric Titration, and Electrode Potential.

Gas Constant.—*See* Gas Law.

Gaseous Volumes, Law of.—*See* Combining Volumes, Law of.

Gas Law.—The laws of Boyle and Charles may be combined to give the expression :—

$$\frac{pv}{T} = \text{const. or } pv = RT,$$

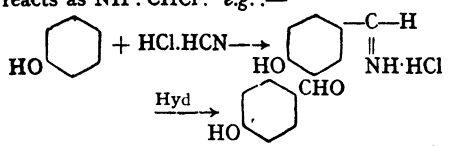
where p = pressure and v = volume of one gram-molecule of a gas at the absolute temperature T. This is known universally as the *Gas Law*. For n gram-molecules the equation becomes $pv = nRT$. R is a constant known as the *Gas Constant*, and has the value 0·082 litre-

atmospheres per degree. R is thus an energy term and is equal to 1·98 calories or $8·2 \times 10^7$ ergs. A gas obeying this law is termed a *perfect* or *ideal gas*, but no gases actually obey the law absolutely. *See* Equations of State.

Gattermann-Koch Reaction.—*See* Gattermann Synthesis (Aldehydes).

Gattermann Method (Reaction).—The preparation of aromatic halogen compounds from the diazo compounds by the use of copper powder; *e.g.* *o*-toluidine diazotised in HCl and treated with copper powder gives *o*-chlortoluene. *Cf.* Sandmeyer Reaction, and Ullmann's Method.

Gattermann Synthesis (Aldehydes).—(1) Benzene and homologues give aldehydes by treating with a mixture of carbon monoxide and hydrochloric acid in the presence of Cu_2Cl_2 or $AlCl_3$. The CO and HCl react as formyl chloride, HCOCl; *e.g.* $C_6H_6 + HCOCl \rightarrow C_6H_5CHO + HCl$. The aldehyde group enters para to any alkyl (etc.) group. Phenols and phenol ethers do not react. *See* following. (2) The aldehydes of the phenols and their ethers may be prepared by an analogous method in which a mixture of HCN and HCl is employed. This reacts as NH : CHCl: *e.g.*:—



This reaction is sometimes known as the *Gattermann-Koch Reaction*. *Cf.* Hoesch Reaction.

Gay-Lussac, Law of.—*See* Combining Volumes, Law of.

Geiger-Nuttall Relation.—An expression connecting the disintegration of a radioactive atom with the range of the expelled alpha particles. It is given by

$$\log \lambda = A + B. \log R,$$

where λ is a constant representing the probability of N particles being in a critical position simultaneously; R is the range of the alpha particle expelled, and A and B are constants. The theory is that N separate particles within the nucleus attain to a critical position independently and simultaneously, this critical position being that which results in disintegration. The relation may also be expressed thus:

$$\log \lambda = Na + \tfrac{3}{2} N. \log R,$$

where λ is the average life of the atom and a is a constant.

Gelatinisation.—The formation of a gelatinous or jelly-like gel by the action of solvents or reagents; *e.g.* the gelatinisation of gun-cotton by solution in ether-alcohol mixtures.

Gelation.—*See* Gels.

Gels.—The name *gel* was originally given by Graham to the precipitated or coagulated colloidal form in contradistinction to the colloidal solutions which he termed *sols*. The action of heat on, or the addition of electrolytes to, emulsoid sols under given conditions results in the precipitation or coagulation of the disperse phase. The process is termed *gelation* (the terms gelatinisation, gelatination, and gelification are also somewhat loosely employed), and the coagulated substance is termed a *gel*. In general, the gels are microscopically heterogeneous. Gelation usually results in a lessened degree of dispersion and a loss of uniform distribution; there is usually a separation from the dispersion medium, and in all cases gels differ from sols in possessing a degree of rigidity. If the gel passes back into the sol when the conditions which produced it are reversed the process is said to be reversible; if not, it is irreversible; *e.g.* the formation of albumin gel from the sol by addition of electrolytes is reversible, but gel-formation by heating is irreversible. Colloids were formerly classed as reversible or irreversible, but it is preferable to apply these terms to a change of state or condition rather than to the substances themselves. Gels may be classified according to the dispersion medium, those in water being *hydrogels*, those in alcohol *alcogels*, and so on. *See* Colloidal State, and Sols.

gem-.—A prefix employed to denote that, in a disubstituted compound, the two substituents are attached to the same carbon atom; *e.g.* *gem*-dimethylsuccinic acid,

$$HOOC.C(CH_3)_2.CH_2.COOH.$$

General Absorption.—*See* Spectrum, Absorption.

General Formulæ.—*See* Formulæ (Chemical).

Geneva Nomenclature.—A system of nomenclature for organic compounds adopted and recommended by an International Conference held in Geneva in 1892 and presided over by Friedel. The system has been fairly extensively adopted, and is particularly useful in naming compounds with multiple functions. It is chiefly employed in the aliphatic series and for certain classes of carbocylic compounds. It is little used for aromatic or benzenoid compounds. Further, the Geneva names are not

often employed for those compounds with well-known names of long standing; *e.g.* acetic acid is not often referred to as ethanoic acid, chloral as trichlorethanal, glucose as hexanepentolal, acetone as propanone, and so on. In general, heterocyclic compounds do not come under the scheme. The following are the main features of the system. The acyclic saturated hydrocarbons are taken as the basis of classification and all compounds represented as derivatives of these, substituents being indicated by certain suffixes or prefixes:—

(1) *Normal Hydrocarbons.*—The suffix *-ane* is employed for the saturated hydrocarbons (paraffins), *-ene* for the olefinic hydrocarbons, and *-ine* for the acetylenic hydrocarbons. Two double bonds are indicated by *-diene*, three by *-triene*, and so on. Two triple bonds are denoted by the suffix *-diine*, three by *-triine*. One double and one triple bond have the suffix *-enine*, two double and one triple *-dienine*, and so on. The carbon atoms in the chain are numbered consecutively or are denoted by Greek letters, and the position of double or triple bonds is indicated by means of these, the numbering or lettering beginning at the terminal carbon nearest the double or triple bond; *e.g.*

	1	2	3	4	5
Pentane	CH_3—	CH_2—	CH_2—	CH_2—	CH_3
2-Pentene	CH_3—	CH=	CH—	CH_2—	CH_3
1,3-Pentadiene	CH_2=	CH—	CH=	CH—	CH_3
2-Pentine	CH_3—	C≡	C—	CH_2—	CH_3
1,3-Pentenine	CH_2=	CH—	C≡	C—	CH_3

(2) *Branched-chain Hydrocarbons.*—The longest normal chain is chosen and the branched chains represented as substituents, using the numbers as above. The numbering begins at the terminal carbon atom nearest the side chain. If there are two side chains which are symmetrically situated numbering is commenced at the terminal carbon atom nearest the simpler side chain; *e.g.*

2-methylbutane—

$$CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2-CH_3$$

3-methyl-4-ethyl-1,5-heptadiene—

$$CH_2=CH-\underset{\displaystyle CH_3}{\underset{|}{CH}}-\underset{\displaystyle C_2H_5}{\underset{|}{CH}}-CH=CH-CH_3$$

(3) *Alcohols.*—These have the suffix *-ol* (*-diol*, *-triol*, etc.); *e.g. ethanol* (ethyl alcohol), *1-propen-3-ol* (allyl alcohol), *1,3-propandiol* (β-propylene glycol).

(4) *Aldehydes.*—The presence of the CHO group is indicated by the suffix *-al* (*-dial*, *-trial*, etc.); *e.g. ethanal* (acetaldehyde), *ethandial* (glyoxal), *propenal* (acrylic aldehyde).

(5) *Ketones.*—These have the suffix *-one* (*-dione*, etc.); *e.g. propanone* (acetone), *butandione* (diacetyl).

(6) *Acids.*—These have the ending *-oic* (*-dioic*, etc.); *e.g. methanoic acid* (formic acid), *dichlorethanoic* (dichloracetic), *propenoic* (acrylic), *ethandioic* (oxalic).

(7) *Amides, Amines, Nitriles.*—These names are retained; *e.g. propanamide* (propionamide), *ethane-nitrile* (acetonitrile).

(8) *Mixed Functions.*—The suffixes given above are combined to give a suffix indicating the kinds and number of the groups present. Thus, for a double bond and OH, *-enol; e.g. propenol* (allyl alcohol); for two double bonds and one OH, *-dienol* (*e.g.* $CH_2OH.CH=CH_2-CH=CH_2$, *1, 3-pentadiene-5-ol*). For double bonds and CO groups, *-enone* (*e.g.* $CH_2=CH.CO.CH_3$, *butenone*); *-dienone* (*e.g.* $CH_2=CH.CO.CH_2.CH=CH_2$, *1, 5-hexadiene-3-one*). Double bonds and COOH groups, *-enoic*, *-dienoic*, *-endioic*, etc. (*e.g.* $CH_2=CH.COOH$, *propenoic acid*). For OH and CHO, *-olal*, *-diolal*, etc. (*e.g.* $CH_2OH.CHO$, *ethanolal*; $CH_2OH.CHOH.CH_2.CHO$, *butane 1, 2-diol-4-al*). For OH and CO, *-olone*, *-diolone*, etc. (*e.g.* $CH_2OH.CH_2.CO.CH_3$, *1, 3-butanolone*; $CH_2OH.CO.CH_2OH$, *propan-1, 3-diol-2-one*). Similarly, CHO and CO have the suffix *-onal*, *-dional*, etc.; COOH and OH, *-olic*, *-diolic*, *-dioldioic*, etc.; COOH and CHO, *-alic*, *-dialic*; COOH and CO, *-onic*, *-dionic*, *-ondioic*, etc.

(9) *Sulphur Compounds.*—The group SH is termed *-thiol*, CSOH is *-thionic*, COSH *-thiolic*, and CSSH *-thionthiolic*; *e.g.* $CH_3.CSSH$ is *ethanthionthiolic acid*.

(10) *Ethers.*—These are named by placing the term oxy- between the names of the two radicals; *e.g.* diethyl ether is *ethane-oxy-ethane*.

(11) *Lactones.*—These have the suffix *-olid*; *e.g.* butyrolactone is *butanolid*.

(12) *Cyclic Compounds.*—The carbocylic compounds have the name of the corresponding acyclic hydrocarbon with the prefix *cyclo-*. For examples of hydrocarbons *see* Cyclo-olefines and Cycloparaffins. The terminations *-al*, *-one*, etc., are retained for the cylic alcohols, ketones, etc.

Geochemistry.—That branch of chemistry which deals with the composition, formation, etc., of rocks. Geological chemistry.

Geometrical Isomerism.—*See* Isomerism, Geometrical.

Gerhardt's Test.—A test for acetoacetic acid in urine. Ferric chloride produces a red colour.

Geuther's Synthesis.—The acetoacetic ester condensation. Two molecules of acetic (etc.) ester are condensed by means of sodium (sodium ethylate). Thus,

$$CH_3COOC_2H_5 + CH_3COOC_2H_5 \rightarrow CH_3COCH_2COOC_2H_5 + C_2H_5OH.$$

The reaction was studied and extended by Claisen, and is now more often referred to as the Claisen ester condensation.

Gibbs-Helmholtz Equation.—*See* Free Energy.

Gladstone and Dales' Formula.—*See* Specific Refraction.

Gliadins.—A group of proteins occurring in the seeds of cereals and characterised by being insoluble in water and absolute alcohol but soluble in 50–70 per cent alcohol. As the gliadins yield relatively larger amounts of proline on hydrolysis, they have been termed *Prolamins* (in America).

Globulins.—Proteins which, like the albumins, are coagulated by boiling their solutions in presence of a little acetic acid. They are distinguished from the albumins by being insoluble in pure water, though soluble in dilute salt solutions, and by being precipitated on saturation with sodium chloride or on half-saturation with ammonium sulphate.

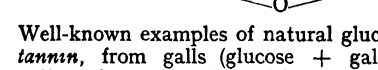
Glucinates.—Beryllates (*q.v.*).

Gluciphores.—A name given to certain radicals or atomic groupings which confer a sweet taste when introduced into the molecule of a tasteless compound. The term is little used.

Gluco-proteins.—A class of proteins occurring in various tissues of the animal body which are characterised by forming a reducing sugar on hydrolysis. They are classified into three groups, viz. (1) *Mucins*, which give a gummy or slimy solution in water or dilute alkali and are precipitated by acetic acid as sticky strands. (2) *Pseudomucins*, which are similar to the mucins, except that they are not precipitated by acetic acid, but are precipitated by alcohol. (3) *Mucoids*, which do not give slimy solutions, are soluble in water and dilute acids and alkalis, and are precipitated as white powders by alcohol.

Glucosans.—Hexose hemicelluloses yielding glucose as the principal product on hydrolysis. *See* Hemicelluloses.

Glucosides.—A class of naturally occurring compounds which are condensation products of monosaccharoses with a variety of other compounds, such as alcohols, phenols, aldehydes, etc. They yield the sugar and the other compounds on hydrolysis. Many of them are derivatives of glucose; hence their name. They are sometimes classified according to the sugar they contain. Thus there are fructosides, mannosides, galactosides, rhamnosides, and so on, those containing an aldose being termed *aldosides* and those with a ketose *ketosides* Some glucosides have been prepared synthetically; *e.g.* methyl-glucoside, to which the following structure has been assigned :—



Well-known examples of natural glucosides are *tannin*, from galls (glucose + gallic acid); *salicin*, from the willow (glucose + saligenin); *amygdalin*, from bitter almonds (glucose + benzaldehyde + hydrocyanic acid). Glucosides yielding HCN on hydrolysis are known as *cyanogenetic glucosides*.

Glucosuria.—That condition of the urine in which glucose or other reducing sugar is present, as, *e.g.*, in diabetes.

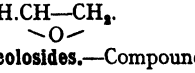
Glutelins.—A group of proteins occurring in plants. They are distinguished from the other classes by being insoluble in water, neutral salt solutions, and alcohol, but are soluble in dilute alkalis. In composition they are distinguished by their high percentage of glutamic acid. Glutenin (from wheat) and legumin (from peas) belong to this class.

Glycerides.—Esters of glycerol. They usually have the suffix *-in*. Thus the formic esters are *formins*, the acetic esters *acetins*. The esters of palmitic (*palmitins*), stearic (*stearins*), and oleic (*oleins*) acids are the chief constituents of many of the natural fats and oils. The glycerides have the prefix *mono-*, *di-*, or *tri-*, according as one, two, or all three of the OH groups are esterified. Two or three different acid radicals may be present yielding *mixed* glycerides.

Glyceryl (Radical).—The tervalent group $CH_2—CH—CH_2$: from glycerol.

Glycides.—Derivatives or polymers of glycide, $CH_2OH.CH—CH_2$.

Glycolosides.—Compounds of the type



where R is an alkyl radical. They are derivatives of the cyclic form of glycollic aldehyde, $CH_2OH.CHO$, and are analogous in structure to the glucosides (*q.v.*).

Glycols.—Acyclic dihydric alcohols. They are classed as diprimary, primary-secondary, secondary-tertiary, ditertiary, etc., according as one or both OH groups are primary, secondary, or tertiary; *e.g.* ethylene glycol, $CH_2OH\ CH_2OH$ (diprimary); α-propylene glycol, $CH_3.CHOH\ CH_2OH$ (primary-secondary); pinacone, $(CH_3)_2\,C\,OH-C.OH.(CH_3)_2$ (ditertiary). *See* Alcohols.

Glycolytic Enzymes.—*See* Sucroclastic Enzymes.

Glycosides.—Glucosides (*q v.*). Term now little used.

Glycyl (Radical).—The group $NH_2\,CH_2.CO-$. The radical of aminoacetic acid (glycine).

Glyoxalidines.—Compounds having the structure

$$\begin{matrix} CH_2-N \\ | \\ CH_2-NH \end{matrix} \diagdown\!\!\diagup C.R,$$

where R is an organic radical. Also termed dihydroglyoxalines. *See* Azoles.

Glyoxalines.—*See* Azoles.

Gmelin's Test.—A test for bile pigments. If a drop of fuming nitric acid is placed in the centre of a thin film of bile it becomes surrounded with rings of green, blue, red, and yellow.

Gold Number.—A quantitative comparative evaluation for the protective action of colloids. It is the weight in milligrams of the colloid which just fails to prevent the change from red to violet in 10 c.cs. of a gold sol (0·0053–0·0058 per cent gold) when 1 c.c. of 10 per cent sodium chloride solution is added to it.

Goldschmidt Process.—*See* Thermite Process.

Goniometer.—An instrument employed for measuring the angles between the faces of crystals.

Graham's Law (Diffusion).—The relative rates of diffusion of any two gases are inversely proportional to the square roots of their densities. If v_1 and v_2 are the rates of diffusion and d_1 and d_2 the densities, then

$$\frac{v_1}{v_2} = \frac{\sqrt{d_2}}{\sqrt{d_1}}$$

Gram-atom.—The atomic weight of an element expressed in grams.

Gram-calorie.—*See* Calorie.

Gram-equivalent.—The equivalent weight of an element or compound expressed in grams. *See* Equivalent Weight, and Normal Solutions.

Grammol.—Gram-molecule (*q.v*).

Gram-molecule.—The molecular weight of an element or compound expressed in grams. The terms *grammol*, *mol*, and *molweight* are also frequently employed. *Cf.* Formula Weight.

Graphic Formulæ.—*See* Formulæ (Chemical).

Gravimetric Analysis.—*See under* Analysis.

Grignard Reactions.—Synthetic organic reactions carried out by means of the Grignard reagents (*q.v.*). A large number of saturated and unsaturated hydrocarbons; primary, secondary, and tertiary alcohols and glycols; ethers; amines; aldehydes; ketones; acids; and organic derivatives of silicon, sulphur, boron, etc., have been prepared by these reactions, which have proved one of the most fruitful sources of synthesis in organic chemistry. The following simple examples will illustrate the use of the Grignard reagents:—

(1) Isopropyl alcohol from acetaldehyde:—

$$CH_3.CHO+CH_3.MgI \rightarrow CH_3.CH<\begin{matrix}OMgI\\CH_3\end{matrix}$$

$$\xrightarrow{H_2O} CH_3\,CH(OH).CH_3+MgI(OH).$$

(2) Pinacone from ethyl oxalate:—

$$\begin{matrix}COOEt\\|\\COOEt\end{matrix} +4CH_3.Mg.I\rightarrow$$

$$\begin{matrix}(CH_3)_2\,C-OMgI\\|\\(CH_3)_2.C-OMgI\end{matrix} (+2Mg(OEt).I.)\xrightarrow{H_2O}$$

$$(CH_3)_2\,C(OH)-C(OH).(CH_3)_2.$$

(3) Phenylethyl ketone from benzonitrile:—

$$C_6H_5CN+C_2H_5.Mg.I\rightarrow C_6H_5C<\begin{matrix}C_2H_5\\N.MgI.\end{matrix}$$

$$\xrightarrow{H_2O} C_6H_5C(\cdot NH).C_2H_5\xrightarrow{H_2O} C_6H_5COC_2H_5.$$

(4) Acetic acid may be synthesised thus:—

$$CH_3.MgI+CO_2\rightarrow CH_3COOMgI\xrightarrow{H_2O}$$
$$CH_3COOH.$$

Grignard Reagents.—Organometallic compounds of magnesium having the general formula R.Mg.X, where R is an organic radical (methyl, ethyl, phenyl, benzyl, etc.) and X a halogen (generally iodine or bromine). *See* Grignard Reactions.

Guaiacum Reaction.—A reaction for blood, depending on the production of a blue colour

on adding a dilute solution of blood to a mixture of tincture of guaiacum (or guaiaconic acid) and hydrogen peroxide.

Guanidines.—Derivatives of guanidine, $NH:C(NH_2)_2$; *e.g.* methyl guanidine, $NH:C(NH_2)NHCH_3$.

Guanyl (Radical).—The group $NH_2.C(:NH).NH-$; from guanidine.

Guldberg and Waage, Law of.—*See* Mass Action, Law of.

Gums.—A class of substances of vegetable origin having sticky or adhesive properties. Many of them yield pentose sugars on hydrolysis and mucic and oxalic acids on oxidation with nitric acid. These may therefore be regarded as consisting chiefly of polymerised pentoses; *e.g.* wood gum yields xylose, gum arabic yields galactose and arabinose and the potassium and calcium salts of arabic acid. *See* Hemicelluloses.

Gunsberg's Reagent.—For testing for free HCl in gastric juice. It consists of two parts of phloroglucinol, one part of vanillin, and thirty parts of rectified spirit. A drop of gastric juice evaporated with a drop of the reagent gives red crystals if free HCl is present.

Guttameter.—An instrument for measuring surface tension by the drop number, the surface tension being calculated from the drop weight.

Gutzeit Test.—A test to distinguish between arsenic and antimony The substance is treated with zinc and sulphuric acid, and the evolved gas allowed to come into contact with a strip of paper moistened with 50 per cent $AgNO_3$. If arsenic is present there is produced a yellow coloration due to the action of the liberated AsH_3 on the silver nitrate. SbH_3, from antimony, does not give this reaction. It is however given by PH_3 and H_2S. *See* Marsh Test.

H

h.—*See* Table of Symbols, p. 157.

Hæmacytometer.—An instrument designed to enumerate the blood corpuscles in a specimen of blood by microscopic examination of a small known volume of the blood on a slide marked off in squares.

Hæmatinics.—Drugs which increase the amount of hæmoglobin in the blood.

Hæmoglobinometer.—An instrument for estimating the hæmoglobin content of a solution of blood by colorimetric comparison with a hæmoglobin solution of known strength.

Hæmolysis.—The liberation of hæmoglobin from the blood corpuscles and its passage into solution. This may occur either by the action of hæmolytic agents, such as saponin, on the surface membrane of the corpuscles, or by the bursting of the corpuscles by osmotic swelling when placed in a hypotonic solution.

Hæmostatics.—Substances applied either locally or internally in order to arrest bleeding; *e.g.* adrenalin and ergot.

Halates.—Salts of chloric, bromic, and iodic acids.

Half-Elements.—The single electrodes of an electrolytic cell; *e.g.* the standard calomel electrode (*q v*); silver in a standard solution of silver nitrate, hydrogen in a standard solution of hydrogen ions (the hydrogen electrode), etc. These are standard half-elements and are employed in conjunction with another half-element for the measurement of the e m.f. of the latter. $Zn \mid ZnSO_4Aq$ and $Cu \mid CuSO_4$.Aq. are the half-elements of the Daniell cell, $Zn \mid$ sat $ZnSO_4$.Aq. and $Hg \mid Hg_2SO_4$ Aq. are the two half-elements of the Clark cell, and so on.

Halides.—The chlorides, bromides, iodides, and fluorides.

Halo-.—A prefix employed to denote presence or content of halogen; *e g.* haloplatinates (chloroplatinates), haloselenates (bromoselenates), halohydrocarbons (*q v.*), halohydrins (*q.v*), etc.

Halochromism (Halochromy).—Certain colourless or feebly coloured compounds yield intensely coloured solutions in acids; *e g.* dibenzalacetone gives a deep orange-red in concentrated sulphuric acid and vermilion in concentrated hydrochloric acid. Triphenylcarbinol also yields coloured solutions in strong mineral acids. The phenomenon is termed halochromy, and is due to salt formation. *Cf.* Chromoisomerism.

Halogen Acids.—Hydrochloric, hydrobromic, hydriodic, and hydrofluoric acids. Also termed *haloid* acids. The other halogen acids containing oxygen, such as bromic, periodic, etc., are generally termed halogen *oxy-acids*.

Halogenation.—The introduction of one or more atoms of a halogen into the molecule of a compound (generally organic). The term usually signifies the substitution of halogen for hydrogen, but is also employed to denote direct addition of halogen to unsaturated compounds. The terms chlorination, bromination, and some-

times iodination, are employed for the process of introducing chlorine, bromine, and iodine respectively.

Halogen Carriers.—Substances which catalyse halogenation reactions; *e g.* ferric chloride, aluminium chloride, iodine, etc. *Cf.* Catalyst Carriers.

Halogen Compounds.—Compounds containing one or more halogens, such as the halogen salts and esters, halohydrocarbons, chloramines, etc.

Halogen Esters.—Esters of the halogen acids; *e g.* methyl iodide, CH_3I, ethyl bromide, C_2H_5Br, etc. Also termed *haloid* esters.

Halogen Hydrides.—The halogen acids (*q v.*).

Halogens.—The elements chlorine, bromine, iodine, and fluorine.

Halogen Salts.—Salts of the halogen acids *i.e.* the chlorides, bromides, iodides, and fluorides. Also termed *haloid* salts.

Halohydrins.—Glycerol esters of the halogen acids; *e g.* α-chlorhydrin, $CH_2Cl.CHOH.CH_2OH$, αβ-dibromhydrin, $CH_2Br\ CHBr.CH_2OH$. The corresponding compounds from glycol are termed ethylene halohydrins; *e g.* ethylene chlorhydrin, $CH_2Cl.CH_2OH$.

Halohydrocarbons.—Halogenated hydrocarbons; *e.g.* the chloro-, bromo-, etc., paraffins, olefines, benzenes, and naphthalenes.

Haloid Acids.—Halogen Acids (*q v*).

Haloid Esters.—Halogen Esters (*q v.*).

Haloid Salts.—Halogen Salts (*q v*).

Halphen Test.—For the detection of cottonseed oil, 3 c.cs. of the sample are treated on the water bath with 3 c.cs. of amyl alcohol and 3 c.cs. of a one per cent solution of sulphur in carbon disulphide. If cottonseed oil is present a red coloration is produced.

Hantzsch's Nitro Reaction.—Isonitro- compounds suspended or dissolved in ether and treated with dry hydrochloric acid or acetyl chloride give a blue coloration.

Harmosones.—A name suggested by Gley for that class of hormones (*q.v.*) which influence growth.

Hayem's Fluid.—A solution of sodium sulphate (5 grams), sodium chloride (1 gram), and mercuric chloride (0·5 gram), in 200 c.cs. water. It is used for diluting the blood used in connection with hæmacytometer tests.

Heat of Absorption.—*See* Heat of Solution.

Heat of Adsorption.—The amount of heat liberated when a given amount of substance is adsorbed by another substance, as, *e.g.*, in the adsorption of gases by charcoal.

Heat of Combustion.—The total heat liberated by the complete oxidation of a given quantity of an element or compound. It is generally expressed in calories per gram-atom or gram-molecule (or formula weight) (*cf.* Calorific Value); *e g.* the heat of combustion of carbon (12 grams) giving CO_2 is 96,980 cal.; that of benzene ($C_6H_6 = 78$ grams) is 784,100 cal.; that for chloroform ($CHCl_3 = 119{\cdot}5$ grams) is 89,200 cal.; and so on. The heat of combustion depends on the initial state of the substance—*i.e.* whether solid, liquid, or gas—and on the state of the products (*e g.* whether the H_2O is liquid or as steam). *See* Equations (Chemical).

Heat of Crystallisation.—The amount of heat liberated when a given amount of substance crystallises from a state of fusion. It is generally expressed in calories per gram-molecule and represents the difference in the energy content of the solid (crystal) and liquid states at the melting point; *e.g.* for acetic acid it has the value 2,770 cal. per mol.

Heat of Dilution.—The amount of heat liberated when a given amount of solvent is added to a fixed amount of a solution of a substance, *e g.* the heat of dilution of a solution of one gram-molecule of NaOH in five gram-molecules of water when fifteen gram-molecules of water are added is 950 cal. Again, when a solution of one gram-molecule of H_2SO_4 in ten gram-molecules of water is diluted by addition of 190 gram-molecules of water there is liberated 2,150 cal.

Heat of Evaporation.—*See* Heat of Vaporisation.

Heat of Dissociation.—The heat liberated or absorbed by the dissociation of one gram-molecule of a compound; *e.g.* $N_2O_4 = 2NO_2 +$ 13,920 cal.

Heat of Formation.—The amount of heat liberated or absorbed in the formation of one gram-molecule of a compound from its elements. The condition of the elements reacting and of the product must be specified; *e.g.* two gram-molecules of hydrogen (4 grams) combine with one gram-molecule of oxygen (32 grams) to give two gram-molecules of water (36 grams). If the latter is in the form of steam at 100° C. there is liberated 118,000 cal. If the H_2O is condensed to liquid at 18° C. the value is 137,000. The heat of formation of water ($H_2O = 18$ grams) is therefore 59,000 cal. for steam and 68,500 for liquid water. The heat of formation of hydrogen iodide ($HI = 128$ grams)

is −3,000 cal., that of silver chloride (AgCl = 143·5 grams) is 29,200 cal. In writing the equations for heats of formation, solids are sometimes indicated by a line under the symbol or formula, gases have a line above, and liquids no line; thus:—

$$\underline{P} + \overline{Cl_3} = PCl_3 + 76{,}000 \text{ cal.}$$

See Heat of Neutralisation, and Hess' Law.

Heat of Fusion.—The amount of heat required to transform a given quantity of substance from the solid to the liquid state at constant temperature; *e.g.* the (latent) heat of fusion of ice is 80 cal. per gram; that for crystalline phosphoric acid is 2,520 cal. per gram-molecule (H_3PO_4 = 98 grams).

Heat of Hydration.—The amount of heat liberated when a given quantity of substance takes up water of constitution; *e.g.* $CaCl_2$ (111 grams) →$CaCl_2.6H_2O$ liberates 21,750 cal. The term is also applied to other cases in which the water taken up is combined in some way, such as, *e.g.*, the hydration of a gel by imbibition of water.

Heat of Ionisation.—The heat liberated or absorbed by the electrolytic dissociation (ionisation) of a compound in water. It is a measure of the difference in the energy content of the dissociated and undissociated molecules. The heat of ionisation of NaOH is −1,290 cal., that of HCl is −1,080 cal., both in decinormal solution. The term has been applied by Ostwald to the energy of formation of a gram-equivalent of ions from a non-ionised element; *e.g.* the heat of formation of a gram-equivalent (32·4 grams) of zinc ions is 16,600 cal.

Heat of Neutralisation.—The heat liberated when a given quantity of an acid is neutralised by a base or *vice versa*. The quantities are generally expressed in terms of gram-molecules of acid or base in solution in a given number of gram-molecules of water; *e.g.* one gram-molecule of HCl (36·5 grams) in 200 gram-molecules of water (3,600 grams) when neutralised with one gram-molecule of NaOH (40 grams) dissolved in a large quantity of water liberates 13,780 cal. The heat of neutralisation of strong acids and bases in dilute aqueous solution, assuming complete dissociation, is approximately constant for all the strong acids and bases, and has the value 13,700 cal. This is due to the fact that such neutralisations amount to the heat of formation of water from its ions; *e.g.* the heat of neutralisation of HBr by NaOH may be represented by the equation:—

$$H^{\cdot} + Br' + Na^{\cdot} + OH' = Na^{\cdot} + Br' + H_2O + 13{,}700 \text{ cal.}$$

Heat of Oxidation.—The amount of heat liberated by the combination of an element with oxygen to give an oxide; *e.g.* Ca (40 grams) →CaO + 145,000 cal.; Fe →FeO + 64,600 cal.; 2Na (46 grams) →Na_2O + 91,000 cal.

Heat of Reaction.—The amount of heat liberated or absorbed in a chemical reaction between given quantities of substances. These quantities are usually expressed in terms of gram-molecules or formula weights. The heat of reaction depends on the state of the reacting substances and of the products. *See* Heat of Combustion, and Heat of Formation.

Heat of Solution.—The amount of heat liberated or absorbed when a given quantity of substance is dissolved in a solvent; *e.g.* the heat of solution of one gram-molecule of sodium iodide (NaI = 150 grams) in 200 gram-molecules of water (3,600 grams) is 1,200 cal.; that for sodium chloride (NaCl = 58·5 grams) in 100 gram-molecules of water (1,800 grams) is −1,200 cal. The heat of solution of gases is usually referred to as *Heat of Absorption*, *e.g.* for HCl (36·5 grams) in 100 gram-molecules of water (1,800 grams) the value is 17,200 cal.

Heat of Sublimation.—The amount of heat required to convert a given quantity of solid to the gaseous state at constant temperature.

Heat of Transition.—The amount of heat liberated or absorbed when a given quantity of one modification of a substance passes over into another, *i.e.* the heat change at the transition point.

Heat of Vaporisation.—The amount of heat required to convert unit quantity of a liquid into the gaseous state at constant temperature (isothermal evaporation); *e.g.* 536 cal. of heat are absorbed in the conversion of one gram of water at 100° C. to steam at 100°.

Heat Theorem.—*See* Nernst's Heat Theorem.

Hehner Value.—The total quantity of water-insoluble fatty acids in a fat or oil expressed as a percentage of the fat or oil. The fat or oil is saponified and the fatty acids liberated from the resulting soap by mineral acids.

Heller's Nitric Acid Test.—A test for albumin in urine. The latter is poured on to the surface of some nitric acid in a test tube. A ring of white precipitate is formed if albumin is present.

Hell-Volhard-Zelinsky Reaction.—The pre-

paration of halogen substituted fatty acids by halogenation of the acid halide. The acid is treated with red phosphorus and the halogen. The halogenated acid halide is then hydrolysed; *e.g.* bromacetic acid is conveniently prepared by treating glacial acetic acid with bromine in presence of red phosphorus; acetyl bromide is first formed and this then brominates readily:—

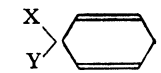
$$3CH_3COOH+P+8Br=3CH_2BrCOBr+HPO_3+2HBr$$

$$CH_2BrCOBr+H_2O=CH_2BrCOOH+HBr.$$

Hemicelluloses.—Condensation products of the pentose and hexose sugars which are intermediate in complexity of constitution between the simple sugars and the celluloses. They may be regarded as produced by the condensation of the sugars with elimination of water; *i.e.* they are *anhydrosugars*. They are naturally occurring and are usually gummy substances. Those produced from the pentoses are termed *pentosans* and have the general formula $(C_5H_8O_4)_n$. To this class belong xylan or wood gum (anhydro-xylose) and araban (anhydro-arabinose). Those derived from the hexoses are termed *hexosans* and have the general formula $(C_6H_{10}O_5)_n$. The glucosans, fructosans, galactans, and mannans belong to this class. The hemicelluloses yield the parent sugars on hydrolysis.

Hemihedral.—*See* Trigonal.

Hemiquinonoid (Hemiquinoid).—A term used for those compounds containing the "half-quinone" structure:—



Hemiterpenes.—Acyclic terpenes having the formula C_5H_8; *e.g.* isoprene, $CH_2:CCH_3CH:CH_2$. *See* Terpenes.

Hempel Apparatus.—An apparatus for gas analysis. It consists essentially of a gas measuring burette (generally 100 c.cs.) and a series of gas pipettes each consisting of two or more connected glass bulbs of about 100-150 c.cs. capacity. These bulbs contain reagents which absorb or react with the constituents of the gaseous mixture to be analysed. The gas from the burette is drawn into the bulbs, shaken with the absorbent, and passed back again into the burette and the diminution in volume read off.

Henry's Law.—The volume of a gas dissolved by a liquid is directly proportional to the pressure of the gas, the temperature being kept constant. This is the *absorption law* for gases in liquids. By Boyle's Law the volume of a gas is inversely proportional to the pressure. The above law may therefore be expressed thus: A given quantity of liquid will absorb the same volume of gas at all pressures, the temperature being kept constant. In other words, the ratio of the concentration of the gas in the gaseous and liquid phases is a constant. This ratio (at 0° C.) is termed the *Absorption Coefficient*.

Heptenyl- (Radical).—The acyclic group $C_7H_{13}-$. The radical of the heptenes.

Heptitols.—The heptahydric alcohols corresponding to the heptoses. They are formed by reduction of the latter and have the formula $CH_2OH(CHOH)_5CH_2OH$.

Heptoses.—*See* Sugars.

Heptyl- (Radical).—The acyclic group $C_7H_{15}-$. The radical of the heptanes.

Hess' Law.—The heat of formation of a compound is the same whether it is formed directly in one reaction or indirectly by a series of reactions; *e.g.* the heat of formation of carbon dioxide from carbon and oxygen ($C+O_2=CO_2$) is 96,980 cal. If the carbon is first oxidised to carbon monoxide ($C+O=CO$) there is liberated 29,000 cal., which is the heat of formation of CO. If now the CO be oxidised to CO_2, 67,980 cal. are liberated. The sum of these is 96,980 as before. Hess' Law may also be stated in more general terms thus: The heat or energy change of a chemical reaction is independent of the course of the reaction and depends only on the initial and final states of the reaction system. *See* Affinity (Chemical).

Hetero-atoms.—*See* Heterocyclic Compounds.

Heterocyclic Compounds.—Cyclic (organic) compounds containing one or more atoms of elements other than carbon in the nucleus. These elements are in most cases nitrogen, oxygen, and sulphur, but other elements also form part of *heteronuclear* rings; *e.g.* arsenic and selenium. The rings are sometimes referred to as *hetero-rings* and the nitrogen, oxygen, etc., atoms as *hetero-atoms*. *See under* Azines, Azoles, and Furans.

Heterogeneous Catalysis.—*See* Catalysis.

Heterogeneous Equilibrium.—Equilibrium in a heterogeneous system; *e.g.* Ice ⇌ Water ⇌ Water Vapour; Rhombic Sulphur ⇌ Monoclinic Sulphur; Red Phosphorus ⇌ Yellow Phosphorus (physical equilibria). Examples of heterogeneous chemical equilibria are: NH_4Cl

(solid) $\rightleftharpoons NH_3$ (gas) + HCl (gas), and $CaCO_3$ (solid) $\rightleftharpoons$ CaO (solid) + CO_2 (gas). *See* Heterogeneous System.

Heterogeneous Reaction.—A chemical reaction in a heterogeneous system (*q.v.*). *See* Heterogeneous Equilibrium.

Heterogeneous System.—A system which is not uniform throughout but consists of parts which are separated from each other by boundary surfaces; *e.g.* any system made up of any two of the three states, liquid, solid, gas, or all three of these. The parts of a heterogeneous system show different physical properties and are mechanically separable; *e.g.* the system, ice—water—water vapour. They may also differ chemically; *e.g.* the system $CaCO_3$—CaO—CO_2.

Heteronuclear.—*See* Heterocyclic Compounds.

Hetero-rings.—*See* Heterocyclic Compounds.

Hewitt's Rule.—For the colour of azo-compounds. The principal oscillation frequency is less (*i.e.* the colour is deeper) the longer the conjugate chain (the chain of alternate single and double bonds) in the molecule. The rule has been modified by Watson, Sircar, and others. *See* Conjugated Double Bonds, and Azo (Compounds).

Hexad (Axis of Symmetry).—*See* Symmetry, Crystal.

Hexagonal (Crystals).—Crystals which may have as many as seven planes of symmetry and one hexad and six dyad axes of symmetry. Metallic zinc and cadmium, lead iodide, etc., crystallise in this system. *See* Symmetry, Crystal.

Hexenyl- (Radical).—The acyclic group C_6H_{11}—. The radical of the hexenes.

Hexitols.—The hexahydric alcohols corresponding to the hexoses, from which they may be obtained by reduction, *e.g.* mannitol, $CH_2OH(CHOH)_4CH_2OH$. All the hexitols have this formula; they are stereoisomeric.

Hexosans.—*See* Hemicelluloses.

Hexoses.—*See* Sugars.

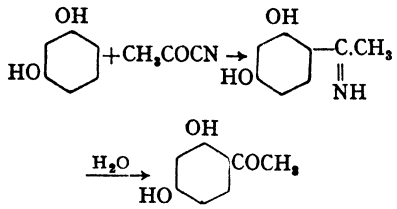
Hexyl- (Radical).—The acyclic group C_6H_{13}—. The radical of the hexanes.

Hippuryl- (Radical).—The group

$$C_6H_5CONHCH_2CO-.$$

The acid radical of hippuric acid (benzoylaminoacetic acid).

Hoesch Reaction.—The synthesis of polyphenol ketones and their derivatives by condensation of the phenol with a nitrile in presence of zinc chloride and HCl; *e.g.* resacetophenone is obtained from resorcinol and acetonitrile thus:—



An extension of the Gattermann phenolaldehyde synthesis (*q.v.*).

Hofmann Reaction.—The formation of amines from amides by treating the latter with chlorine or bromine in the presence of caustic soda or potash (or alkali hypobromite or hypochlorite). Thus:

$R.CONH_2 \rightarrow R.CONHBr \rightarrow RN{:}CO \rightarrow R.NH_2$.

The first product is a bromamide. This then loses HBr and the product undergoes rearrangement, the radical R migrating from carbon to nitrogen to give an isocyanide. The latter then hydrolyses to the amine. The reaction is sometimes called the Hofmann Rearrangement.

Another reaction due to Hofmann is the formation of the homologues of aniline from the corresponding alkylanilines, the alkyl group migrating from the nitrogen into the benzene ring. The reaction is carried out by heating the hydrochloride of the alkylaniline to 250—350°; *e.g.* methylaniline, $C_6H_5NHCH_3$, gives *p*-toluidine, $CH_3.C_6H_4.NH_2$. Exhaustive Methylation (*q.v.*) is also a Hofmann reaction.

Hofmann Rearrangement.—*See* Hofmann Reaction.

Hofmeister Series.—A sequence of effect, observed by Hofmeister, of a series of salts having the same cation but different anions, in salting out (coagulating) neutral albumin from solution. Taking the concentrations in gram-molecules per litre of the sodium salts of various acids required to salt out the same albumin sol at 30–40° C., the series found was:—

Citrate	0·56
Tartrate	0·78
Sulphate	0·80
Acetate	1·69
Chloride	3·62
Nitrate	5·42
Chlorate	5·52
Iodide, Thiocyanate	Do not salt out in saturated solution.

The series is often written qualitatively thus: $SCN < I < ClO_3 < NO_3 < Cl < CH_3COO < SO_4 <$ tartrate $<$ citrate. A corresponding series exists for cations; viz. $NH_4 < Li < Cs < Na < Rb < K$. These series also hold for other effects.

Holohedral.—*See* Symmetry, Crystal.

Holoquinonoid (Holoquinoid).—*See* Quinones.

Homo-.—A prefix sometimes employed in naming an organic compound to denote that the compound is a homologue (usually one differing by an additional CH_2) of the compound to whose name the prefix is added; *e g.* phthalic acid, $HOOC.C_6H_4.COOH$, and homophthalic acid, $HOOC.C_6H_4CH_2COOH$; camphoric acid, $C_8H_{14}(COOH)_2$, and homocamphoric acid $C_9H_{16}(COOH)_2$ *Cf.* Nor-.

Homochromoisomerism.—A name given by Hantzsch to that class of isomerism in which different structural modifications (stereoisomers) of a compound have the same colour and identical absorption spectra; *e g* the syn- and anti- benzaldoximes. *Cf.* Chromoisomerism.

Homocyclic Compounds.—Ring compounds in which the ring or nucleus is composed of atoms of one element. Generally employed to denote the carbocyclic, as distinct from the heterocyclic, compounds. The term is synonymous with isocyclic.

Homogeneous Catalysis.—*See* Catalysis.

Homogeneous Equilibrium.—Equilibrium in a homogeneous system; *e g.* equilibrium between salts (or ions) in solution; or a gas and its gaseous dissociation products. *See* Chemical Equilibrium, Dissociation (Gaseous), and Electrolytic Dissociation.

Homogeneous Reaction.—A reaction in a homogeneous system (*q.v.*).

Homogeneous System.—A uniform system, every part of which is identical in chemical and in general physical properties; *e.g.* a gaseous mixture, or a salt solution.

"Homoisochemite Law."—A generalisation that to every colloidal substance in the mineral kingdom (mineral hydrogels) there exists a corresponding crystalline form. A name proposed by Cornu.

Homologous Series.—The members of the paraffin series of hydrocarbons—methane, CH_4; ethane, C_2H_6; propane, C_3H_8; butane, C_4H_{10}; etc., differ from each other in composition by CH_2. So also do the olefines—ethylene, C_2H_4; propylene, C_3H_6; butylene, C_4H_8; etc.; the acetylenes—acetylene, C_2H_2; methylacetylene, C_3H_4; etc.; the benzenes—benzene, C_6H_6; toluene, C_7H_8; ethylbenzene, C_8H_{10}; etc. Such series are termed *homologous* and the relationship is termed *homology*. The individual members of a homologous series are termed *homologues*.

Homologous Spectra.—The spectra of some chemically related elements, *e.g.* the alkali metals, show a relationship such that each may be resolved into a series of several spectra in such a way that for every line in one spectrum of the series there is a corresponding line in each of the spectra of the other elements in the same series. The spectra in such a series are said to be homologous.

Homologues.—*See* Homologous Series.

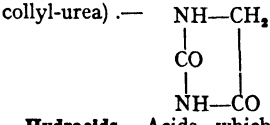
Homology.—*See* Homologous Series.

Hormones.—Substances produced by certain organs of the body which have a specific action on other organs to which they are carried in the blood stream, and thus influence the general or specific metabolic functions of the body. They link up or co-ordinate the activities of certain organs with those of other organs; *e.g* when food enters the duodenum a hormone—secretin—is produced which is transported by the blood to the pancreas. It activates the latter so that a digestive juice is supplied to the duodenum. Practically nothing is yet known of the chemistry of these substances.

Hübl Method.—For the determination of the iodine value (*q v.*) of fats and oils. An alcoholic solution of iodine and mercuric chloride is employed. The fat or oil is dissolved in chloroform and treated with a known volume of this solution. The excess iodine is titrated with thiosulphate.

Hudson's Rule.—The value for the rotatory power of any asymmetric end group—*e g.* CHO—of the monosaccharoses is a constant; *i.e* it is independent of the rest of the molecule. Similarly, the rotatory power of the rest of the molecule is independent of the end group; *e.g.* the group $>CHOH$ has the same rotatory power whether in glucose, xylose, lactose, etc.

Hydantoins.—Derivatives of hydantoin (glycollyl-urea).—



Hydracids.—Acids which do not contain oxygen, such as the halogen acids. The term is not often employed.

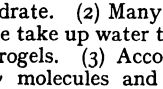
Hydramines.—The hydroxyalkylamines; *e.g.* hydroxyethylamine, $HO.C_2H_4.NH_2$.

Hydrate Theory.—*See* Hydration, and Solvation.

Hydrates.—Molecular compounds obtained by the combination of water with another compound; *e.g.* calcium chloride hexahydrate, $CaCl_2.6H_2O$; sodium sulphate decahydrate, $Na_2SO_4.10H_2O$; hydrogen bromide dihydrate, $HBr.2H_2O$, etc. Some compounds form several hydrates; *e.g.* lead oxide forms two, $2PbO.H_2O$ and $3PbO.H_2O$; and ferric chloride four, viz. $2FeCl_3.12H_2O$, $2FeCl_3.7H_2O$, $2FeCl_3.5H_2O$, and $2FeCl_3.4H_2O$. Hydrates are usually characterised by definite physical properties, such as solubility and vapour pressure. Certain compounds are sometimes referred to as hydrates which are generally regarded as hydroxy compounds; *e.g.* chloral hydrate, $CCl_3CH(OH)_2$ or $CCl_3CHO.H_2O$; aluminium hydrate $Al(OH)_3$ or $Al_2O_3.6H_2O$. *See* Hydration, Hydroxides, and Molecular Compounds.

Hydration.—In general, the addition of water to a substance, the water being combined in some way, as distinct from moistening or solution. (1) The addition of water to a compound to form a hydrate. (2) Many substances in the colloidal state take up water to a certain extent forming hydrogels. (3) According to the *Hydrate Theory* molecules and ions in aqueous solution combine with one or more molecules of water to give hydrates in solution. The molecules of water itself "hydrate" (associate) forming "*hydrols*," $2(H_2O)$ dihydrol, $3(H_2O)$ trihydrol, etc. Ice is largely composed of the latter and liquid water of the dihydrol.

Hydrazi-Compounds.—Compounds containing the grouping , *e.g.* hydrazibenzil,



Hydrazides.—Acylated derivatives of hydrazine (acid hydrazides); *e.g.* $CH_3CO.NH.NH_2$.

Hydrazidines.—Compounds having the formula $R.C(NH_2) : N.NHR'$, where R and R' are organic radicals; *e.g.* ethenyl-phenylhydrazidine, $CH_3C(NH_2) : N.NHC_6H_5$.

Hydrazimethylenes.—Derivatives of hydrazimethylene, .

Hydrazines. — Derivatives of hydrazine, $H_2N.NH_2$; *e.g.* phenylhydrazine, $C_6H_5NH.NH_2$. *Cf.* Hydrazo-Compounds.

Hydrazoates.—Salts of hydrazoic acid, $H.N_3$. More frequently termed azides or azoimides. *See* Azides

Hydrazo-Compounds.—Compounds containing the hydrazo- group, —NH.NH—; *e.g.* hydrazobenzene, $C_6H_5.NH.NHC_6H_5$.

Hydrazo (Group).—The group —HN.NH—.

Hydrazones.—Compounds having the formula $R : N.NH_2$, where R is an alkyl or aryl radical. They are formed by the condensation of aldehydes or ketones with hydrazine; *e.g.* benzaldehyde hydrazone, $C_6H_5CH : NH.NH_2$. The better-known compounds of this class are the phenylhydrazones (*q.v.*).

Hydrazonium Compounds.—Compounds of the type $NH_2—N(R)_3.X$, where $(R)_3$ are three alkyl or aryl radicals and X is an acid radical; *e.g.* phenyldiethylhydrazonium iodide, $NH_2—N(C_6H_5)(C_2H_5)_2$ I.

Hydrazoximes.—Compounds containing hydrazine (or substituted hydrazine) and oxime groups, *e.g.* methylglyoxal-phenylhydrazoxime, $CH_3C(N NHC_6H_5).CH : N.OH$, from the oxime of methylglyoxal and phenylhydrazine.

Hydrides.—Compounds of the elements with hydrogen, *e.g.* phosphorus trihydride (phosphine), PH_3; calcium hydride, CaH_2; sodium hydride, NaH, etc. Such compounds as the halogen acids are also hydrides, but are not usually referred to as such The hydrides of carbon are classed together as hydrocarbons. There is a large number of these and they form the basis of the so-called carbon or organic compounds.

Hydrion.—The hydrogen ion, H^+.

Hydro-.—A prefix denoting the presence of hydrogen in a compound; *e.g. hydro*chloric acid, HCl. It is also employed before the names of organic compounds to denote addition of hydrogen; *e.g.* benzene, $C_6H_6 \rightarrow$ *tetrahydro*-benzene, C_6H_{10}; quinone $\rightarrow$ *hydro*quinone, and so on.

Hydroaromatic (Compounds). — Compounds containing partially or completely reduced benzene nuclei; *e.g.* the cyclo-olefines (*q.v.*), cycloparaffins (*q.v.*), hydronaphthalenes, etc., and their derivatives.

Hydrocarbo-bases.—*See* Alkyls.

Hydrocarbons.—Compounds containing only carbon and hydrogen. *See under* Paraffins, Olefines, Cyclo-, and Geneva Nomenclature.

Hydrocyanides.—*See* Cyanhydrins.

Hydrocyclic.—A term sometimes applied to the hydroaromatic compounds (*q.v.*).

Hydrogels.—*See* Gels.

Hydrogenation.—In general, the addition of hydrogen to the molecule of a compound; *i.e.* chemical combination with hydrogen. The

term is more usually reserved for the addition of hydrogen to unsaturated organic compounds; *e.g.* benzene to hexahydrobenzene and naphthalene to tetrahydronaphthalene (tetralin); olefines to paraffins, such as oleic to stearic acid (which occurs in fat-hardening). Aldehydes and ketones to alcohols, and similar reactions, are usually referred to as reductions, but a sharp line cannot be drawn between the two terms.

Hydrogen Halides.—The halogen acids (*q.v.*).

Hydrols.—(1) Secondary alcohols derived from diphenylketone, *i.e.*, derivatives of $(C_6H_5)_2.CHOH$; *e.g.* Michler's Hydrol, *p-p'*-tetramethyldiaminodiphenyl carbinol,

$(CH_3)_2N.C_6H_4\,CH(OH).C_6H_4.N(CH_3)_2$.

(2) *See* Hydration

Hydrolysis.—In general, a reaction between water and another compound in which the water splits up into H and OH, one of the products combining with the former and one with the latter. Such *hydrolytic* reactions may be represented by the general equation:—

$$AB + H_2O = AH + BOH;$$

e.g. the hydrolysis of ethyl acetate.—

$$CH_3COOC_2H_5 + H_2O = CH_3COOH + C_2H_5OH.$$

Many salts of weak bases or weak acids are more or less extensively hydrolysed in aqueous solution; *e.g.* sodium phenate, C_6H_5ONa, is hydrolysed to phenol, C_6H_5OH, and sodium hydrate, NaOH, aluminium trichloride, $AlCl_3$, is hydrolysed to the trihydrate, $Al(OH)_3$, and hydrochloric acid. The term hydrolysis is often employed when the water is replaced by *hydrolytic reagents*, such as $NaOH, KOH, Ca(OH)_2$, etc., the reaction being similar except that the Na, K, Ca, etc., salts of the acids are formed instead of the free acids. Certain enzymes also act hydrolytically. The term hydrolysis covers a large number of important reactions, such as the conversion of nitriles to acids, $R\,CN \rightarrow R.COOH$; removal of acyl radicals, $R\,SO_3H \rightarrow R\,H + H_2SO_4$, $R.NHX \rightarrow R.NH_2 + HX$, etc. *See* Saponification.

Hydrolytic.—*See* Hydrolysis.

Hydrolytic Enzymes.—Enzymes which react by hydrolysing certain compounds. *See* Lipoclastic, Proteoclastic, and Sucroclastic Enzymes.

Hydrometer.—An instrument for measuring the specific gravity of liquids. The commoner types consist of a weighted glass bulb with a glass stem attached which has a graduated scale. The hydrometer floats in the liquid, the surface of which is level with one of the graduations on the scale so that the specific gravity may be read off directly. *See* Baumé Hydrometer, and Twaddell Hydrometer.

Hydrophile (Colloids).—*See* Lyophile (Colloids).

Hydrophobe (Colloids).—*See* Lyophobe (Colloids).

Hydrosols.—*See* Sols.

Hydrosulphides.—Compounds containing the group $-SH$; *e.g.* potassium hydrosulphide, KSH. The organic hydrosulphides are known as mercaptans (*q.v.*).

Hydrotetrazones.—Compounds derived from $CH_2 \cdot N\,NH.NH\,N : CH_2$; *e.g.* $PhCH : N\,NPh\,NPh.N . CHPh$ (Ph = phenyl).

Hydroxamic Acids.—Compounds of the formula $R.C(\,N.OH)\,OH$, *e.g* benzhydroxamic acid $C_6H_5\,C(\cdot N\,OH)\,OH$. Also termed *hydroximic* acids.

Hydroxides.—Compounds which may be regarded as derived by replacing one hydrogen atom in each of one, two, three, or more molecules of water by one or more atoms of another element. Thus one atom of a univalent element forms the hydroxide M OH, one of a bivalent $M(OH)_2$, and one of a tervalent $M(OH)_3$; *e.g.* potassium hydroxide, KOH, barium hydroxide, $Ba(OH)_2$, and ferric hydroxide, $Fe(OH)_3$. Most of the hydroxides—the metallic hydroxides—are basic, those of the non-metals acidic, *e.g.* $P(OH)_3$ or H_3PO_3, phosphorus acid. The higher hydroxides may be regarded as derived by the addition of water to the oxide, and are sometimes referred to as hydrated oxides; *e.g.* $CaO + H_2O = Ca(OH)_2$; $Fe_2O_3 + 3H_2O = 2Fe(OH)_3$. Ammonia and the ammonium bases also form hydroxides; *e.g.* tetramethylammonium hydroxide $(CH_3)_4\,N.OH$. The acidic hydroxides, $P(OH)_3, As(OH)_3, B(OH)_3$, etc., are not usually referred to as hydroxides, the term being used almost entirely for the metallic or basic hydroxides. *See* Hydrates.

Hydroximic Acids.—*See* Hydroxamic Acids.

Hydroxy-.—A prefix denoting the presence of one or more hydroxy groups in the molecule of a compound, *e.g.* hydroxyacetic acid (glycollic acid), $CH_2OH.COOH$; 1, 3, 5-trihydroxybenzene (phloroglucinol), etc.

Hydroxy-acids.—Organic carboxylic acids containing one or more hydroxy groups in the molecule. They form a large and important class of compounds, many of them occurring naturally; *e.g.* lactic acid, $CH_3CHOH.COOH$; glycollic acid, $CH_2OH.COOH$; malic acid, $HOOC.CHOH.CH_2.COOH$; tartaric acid, $HOOC.CHOH.CHOH.COOH$; citric acid,

$HOOC.CH_2.CHOH.CH_2.COOH$; etc. The last three acids together with a few others are known as the vegetable acids.

Hydroxylamino- (Radical).—The group $-NH.OH$.

Hydroxylation.—The introduction of one or more hydroxy groups into the molecule of an organic compound to give a hydroxy- compound; *e.g.* benzene → phenol. *See* Hydroxy-acids.

Hydroxyl (Hydroxy) (Group.)—The univalent group $-OH$. When attached to an alkyl radical it is termed *alkylic hydroxyl* (*e.g.* in ethyl alcohol); when present in an aromatic nucleus it is termed *phenolic hydroxyl* (*e.g.* in phenol or naphthol), and when present as part of a carboxyl group it is termed *acidic hydroxyl* It is the characteristic group of the hydroxides. *See* Bases, Hydroxides, Hydrolysis, and Hydroxyl Ion.

Hydroxyl Ion.—The hydroxyl group when ionised in solution takes on one negative charge and becomes the hydroxyl ion. It is usually written as OH' or OH^-.

Hydroxymethylene (Group).—The group $=CH.OH$; *e.g.* hydroxymethyleneacetone, $CH_3CO.CH = CH.OH$.

Hygroscopicity.—The absorption and retention of moisture from the atmosphere by a substance. The degree of hygroscopicity depends on the nature of the substance and on the humidity of the atmosphere.

Hylotropic.—A term given by Ostwald to those substances which can undergo a change of phase (*e.g.* liquid → vapour) without change of composition. This embraces all compounds which can undergo any process, such as distillation, which involves a change of state. The term has a broader meaning than azeotropic. *See* Azeotropic Mixtures.

Hyperchromic.—This term has been applied to the effect produced by certain substituents in increasing the depth of the absorption bands (increase of the height of the absorption curve) of a compound.

Hypertonic Solution.—*See* Isotonic Solution.

Hypnotics.—Drugs which induce deep sleep. A noted example is chloral hydrate.

Hypo-.—A prefix signifying "less than" or "under." It is generally used to denote a lower content of oxygen; *e.g.* nitrous acid, HNO_2, and hyponitrous acid, $HNO(H_2N_2O_2)$; potassium chlorite, $KClO_2$ and potassium hypochlorite, $KClO$; bismuthous oxide, Bi_2O_3, and hypobismuthous oxide, Bi_2O_2.

Hyposulphates.—*See* Dithionates.

Hypotonic Solution.—*See* Isotonic Solution.

Hypsochromes.—*See* Bathochromes.

Hypsoflores.—Those groups which, when introduced into the molecule of a fluorescent compound, shift the absorption bands towards the ultra-violet.

Hysteresis.—A term signifying a lag or retardation in the assumption of a stable condition. Systems in a metastable state, suspended transformations, etc., are instances of hysteresis. *See* Metastable Equilibrium.

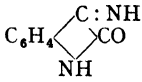
I

i.—*See* van't Hoff Factor.

Ideal Gases.—*See* Gas Law.

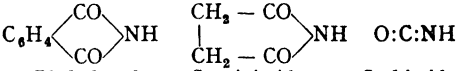
Imbibition.—A term applied to the absorption of water or other liquid by emulsoid gels. It is accompanied by contraction, and evolution of heat.

Imesatins.—Derivatives of β-imino-isatin:—



Imidazoles.—Iminazoles. *See* Azoles.

Imides.—Compounds obtained by replacing the anhydride oxygen of acid anhydrides by NH, *e.g.*



Phthalimide Succinimide Carbimide

Cf. Amides, Amines, Imines, and Anils.

Imido-chlorides.—*See* Imino-chlorides.

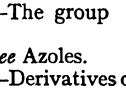
Imido-ethers.—*See* Imino-ethers.

Imidogen.—The divalent group $>NH$. *See* Imides, and Imines.

Imido Group.—The group $>NH$ as present in imides (*q.v.*).

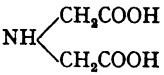
Iminazoles.—*See* Azoles.

Iminazolones.—Derivatives of iminazolone. —



Imines.—Compounds containing the imino group. The term is more often employed for those compounds in which the N is doubly linked to carbon, as, *e.g.*, in the imino-ethers, aldimines, etc. (*see* these). It is, however,

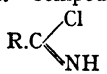
also used in certain cases where the N is linked to two carbon atoms; *e.g.*



Imino-diacetic acid

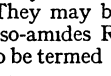
Compounds of the type R.NH.R', where R and R' are alkyl or aryl radicals, are generally classed as secondary amines. *Cf.* Imides.

Imino-chlorides.—Compounds of the type



where R is an aryl or alkyl radical; *e.g.* $CH_3.CCl:NH$. They may be regarded as acid chlorides of the iso-amides R C(OH) : NH, and may therefore also be termed *Imido-chlorides*.

Imino-ethers.—Compounds of the type



e.g. benziminoether, $C_6H_5.C(OC_2H_5):NH$. Also termed *imido-ethers*.

Imino Group.—The group NH as present in imines; *i.e.* it is usually doubly linked to carbon, R = NH. This distinguishes it from the imido group, but there are exceptions (*see* imines). The term imido is still employed by some for both types.

Iminohydrins.—*See* Iso-amides.

Iminoquinols.—*See* Quinols.

Immunochemistry.—That branch of biochemistry which deals with the chemical changes involved in the phenomena concerned in natural or imparted immunity (non-susceptibility) to disease.

Indamine Reaction.—A test for *para*-diamines. When oxidised with neutral ferric chloride in presence of aniline they yield an intense blue coloration (indamine), going to red on boiling.

Indamines.—Compounds obtained by the oxidation of *para*-diamines + another amine; *e.g.*

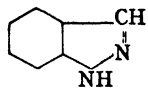
$$\underset{\text{p-phenylene-diamine}}{NH_2.C_6H_4.NH_2} + \underset{\text{aniline}}{C_6H_5.NH_2} \rightarrow$$

$$NH_2.C_6H_4.N:C_6H_4:NH$$

indamine

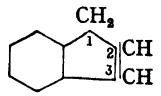
Cf. Indophenols.

Indazoles.—Derivatives of indazole (benzopyrazole) :—



See Indoles and Azoles.

Indenes.—Derivatives of indene :—



The 2, 3-dihydroindene is termed indan.

Indestructibility of Matter, Law of.—This generalisation is commonly summed up by saying that "matter can neither be created nor destroyed." As an experimental law it may be expressed thus: "There is no loss of weight of a system by reason of any chemical or physical changes which can be made to take place in it." The generalisation is also known as the Law of Conservation of Matter (or Mass), and the Law of Persistence of Weight.

Indicators.—Compounds whose colour in solution changes with change in the hydrogen ion concentration of the solution. Broadly speaking, they are one colour in acid solution and another in alkaline solution. They are thus used in volumetric analysis (acidimetry and alkalimetry) for determining the end point in a titration. Actually, indicators only show colour changes over certain ranges of hydrogen ion concentration. Thus methyl orange is red in solutions having $p_H = 2{\cdot}9$ or less, and yellow if $p_H = 4{\cdot}0$ or more. Thus it changes colour from red to yellow as the concentration of hydrogen ions changes from $10^{-2\cdot9}$ to 10^{-4} grams per litre. Phenolphthalein is colourless in solutions having $[H^+] = 10^{-8}$ or more, and pink in solutions whose $[H^+]$ is 10^{-10} or less. Phenol red has a p_H range of 6·8–8·4; methyl red 4·2–6·3, and so on.

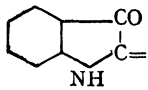
There is another class of indicator which shows the end point of a reaction by a colour change depending on the formation of a new compound, as, *e.g.*, starch, which forms a blue compound with iodine and is used in iodometry, potassium chromate in silver nitrate estimations, etc. Indicators may therefore be defined as compounds which show the end of a chemical reaction by a more or less sharp change of colour.

Indifferent Point.—That point in a system of two or more components in two phases at which

the composition of the two phases becomes identical.

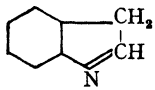
Indigoid.—A name given to the family of dyestuffs derived from indigo and its related compounds and containing the chromogen $-CO-C=C-CO-$.

Indogenides.—Compounds containing the grouping



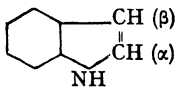
e.g. indigo. Coumarone and oxy-thionaphthene (the oxygen and sulphur analogues) form the corresponding oxy- and thio- indogenides.

Indolenines.—Derivatives of

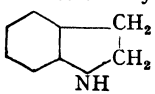


which is an isomeric form of indole. *See* Indoles.

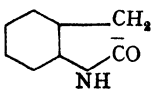
Indoles.—Derivatives of indole (benzopyrrole) :—



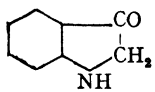
Indolines.—Derivatives of dihydroindole :—



Indolinones.—Derivatives of keto-indolines :—



α



β

Indophenols.—Compounds obtained by the oxidation of a mixture of a *para*-aminophenol and a phenol ; *e.g.*

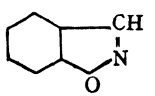
$$NH_2.C_6H_4.OH + C_6H_5.OH \rightarrow$$

p-aminophenol phenol

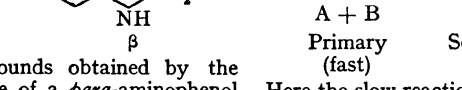
$$O:C_6H_4:N.C_6H_4.OH$$

indophenol

Indoxazines.—Derivatives of benzisoxazole :—



Induced Alternate Polarity (Theory of).—A theory proposed by Lapworth and Robinson. In organic compounds generally there will be one atom in a chain, usually O, N, Cl, etc., which will acquire definite polarity (electric charge) through its great tendency to complete an already nearly complete octet of electrons. Thus it will not exactly share electrons with the neighbouring atom, as Lewis postulates, but will actually appropriate them or so strongly tend to do so that a disturbance in the external conditions (due, say, to the approach of another molecule) will cause it to appropriate them outright. It thus becomes charged, say, negatively. The next atom, having lost electrons to the first, will the more readily lose more of them, and the third atom in the chain will be enabled to complete its octet at the expense of the second and fourth. The net result is the development of alternately positively and negatively charged atoms in the chain, *e.g.* the arrangement of electrons in the molecule of allyl chloride would tend to become



because of the strong tendency of chlorine to complete its octet. The N, O, Cl. etc. atom is termed the *key atom*. *See* Lewis-Langmuir Theory.

Induced Reactions.—Certain reactions which normally proceed very slowly go much more quickly if a certain second and faster reaction is proceeding at the same time in the same system. The first reaction is said to be induced by the second. Generally there are three substances taking part and the reactions may be expressed thus :—

A + B	A + C	A + B + C
Primary (fast)	Secondary (slow)	(fast)

Here the slow reaction A + C is induced by the simultaneous fast reaction A + B. A is termed the *actor* and is usually an oxidising or reducing agent, B is the *inductor*, and C the *acceptor* ; *e.g.* the oxidation of arsenic trioxide by bromic acid in presence of sulphur dioxide. Here the secondary slow reaction is $HBrO_3 + As_2O_3$, and the primary fast reaction $HBrO_3 + SO_2$. $HBrO_3$ is the actor, SO_2 the inductor, and As_2O_3 the acceptor.

The term *acceptor* is also employed in enzyme chemistry ; *e.g.* fresh milk contains an enzyme

which reduces methylene blue if formaldehyde is present, the aldehyde being oxidised to formic acid. This reaction is explained as being due to the enzyme splitting water so that nascent hydrogen is taken up by the methylene blue and the oxygen oxidises the aldehyde. The methylene blue is here said to act as acceptor for the hydrogen, thus enabling the aldehyde to be oxidised.

Inductor.—*See* Induced Reactions.

Indyl (Radical).—The α- or β-univalent radical of indole. *See* Indoles.

-ine.—*See* Geneva Nomenclature.

Inhibition Period.—It has been found that if an emulsion be stabilised by addition of a colloid (*e.g.* a benzene-water emulsion stabilised with gelatin) and a de-emulsifying agent (NaOH) be added immediately, de-emulsification takes place at once. If, however, the emulsion be allowed to stand for some time and the agent added, separation only takes place after an interval, termed the inhibition period.

Inorganic Ferments.—A name given by Bredig to the metallic sols in view of their strong catalytic action, which resembles that of the enzymes or organic ferments.

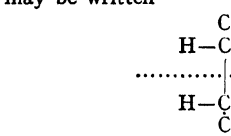
Intensity Factor.—*See* Capacity Factor.

Interface.—The surface of separation between two phases.

Intermolecular Reaction.—A reaction taking place between two or more separate molecules. *Cf.* Intramolecular Reaction.

Internal Amides.—*See* Lactams.

Internal Compensation.—Optically inactive compounds whose inactivity is due to the presence of asymmetric carbon atoms whose configurations within the molecule are such that each exerts an equal and opposite effect to the other are said to be *internally compensated*. Mesotartaric acid is an example. Its formula may be written



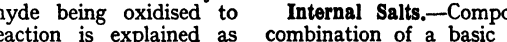
Each half of the molecule about the dotted line is a mirror image of the other, and hence the optical effect of the asymmetry is mutually cancelled out. *See* Asymmetry, Molecular; and Optical Activity. *Cf.* External Compensation.

Internal Condensation.—*See* Condensation, and Endo-condensation.

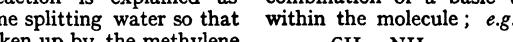
Internal Esters.—*See* Esters.

Internal Ethers.—*See* Ethers.

Internal Salts.—Compounds formed by the combination of a basic with an acidic group within the molecule; *e.g.* taurine,



and sulphanilic acid,



Intra-annular Tautomerism.—A type of tautomerism in cyclic compounds involving a change of valencies across the ring; *i.e.* in one isomer there is a simple ring and in the other a bicyclic ring. *See* Isomerism, Ring-chain.

Intramolecular Change (Rearrangement).—A change taking place within a molecule whereby an isomer of the compound is formed. The change takes the form of a wandering or migration of an atom or group from the atom to which it was combined to some other atom, so that it now occupies a new position in the molecule. The change also sometimes results in a rearrangement of bonds, double to single or *vice versa*. Such changes are numerous and important in organic chemistry. *See, e.g.*, Hofmann's Reaction, Benzidine Transposition, Semidine Transposition, and Molecular Transposition. *See also under* Isomerism, and Isomerisation.

Intramolecular Reaction.—A reaction in which one part of a molecule reacts with another part; *i.e.* the reaction takes place within the molecule. *Cf.* Intermolecular Reaction. *See* term above *and also* Condensation, and Molecular Transposition.

Invariant System.—A heterogeneous equilibrium system which has no degrees of freedom. *See* Phase Rule.

Inversion.—*See* (1) Isomerism, Cis-trans; (2) Oximes; (3) Optical Inversion; and (4) Walden Inversion.

Inversion Temperature.—Transition Temperature. *See* Transition Point. *See also* Joule Thomson Effect.

Iodination.—*See* Halogenation.

Iodine Value (Number).—The amount of iodine absorbed by a given quantity of a fat, oil, or wax. It is usually expressed as parts by weight of iodine absorbed by 100 parts of substance; *i.e.* as a percentage. In practice the substance is treated with a solution of iodine chloride ICl, and the ICl absorbed estimated as iodine. The ICl is taken up by the double or triple bonds in the molecule of the

fat, etc. The iodine value is a useful constant for evaluating commercial oils, fats, etc.; *e.g.* the iodine value of cottonseed oil is 105–115; linseed oil, 175–200; coco-nut oil, 8·5–9·5; tallow, 35–40, and so on. *See* Hübl Method, and Wijs Method.

Iodism.—A pathological state of the human body resulting from the use of iodides (in syphilis, etc.), but said to be due not to the iodide but to small quantities of iodate present as impurity.

Iodometry.—That branch of volumetric analysis in which estimations are made by means of standard iodine. An excess of iodine is used and the excess estimated by means of standard thiosulphate. The characteristic equation of iodometry is

$$I_2 + Na_2S_2O_3 = 2NaI + Na_2S_4O_6.$$

In some cases (oxidations) the iodine is used direct without thiosulphate; *e.g.* in the estimation of arsenites,

$$As_2O_3 + 2I_2 + 2H_2O = As_2O_5 + 4HI.$$

Iodonium Compounds.—Compounds of the formula $(R)_2.I.X$, in which the iodine acts tervalent. R is an organic radical and X a negative radical, OH, NO_3, etc, *e.g.* diphenyliodonium nitrate, $(C_6H_5)_2.I\,NO_3$. *See* Onium Compounds.

Iodoso- (Compounds).—Compounds containing the iodoso group, —IO; *e.g.* iodoso-benzoic acid, $C_6H_4(IO)COOH$.

Iodoxy- (Compounds).—Compounds containing the iodoxy group, $-IO_2$; *e.g.* iodoxybenzene, $C_6H_5IO_2$.

Ionic Conductivity.—The electrical conductivity of the individual ions. If Λ is the equivalent conductivity of an electrolyte, this may be represented as the sum of the conductivities of the two ions, *i.e.*

$$\Lambda = \alpha l_u + \alpha l_v,$$

where $l_u = Fu$, $l_v = Fv$, α = degree of dissociation; u and v are the ionic mobilities of the cation and anion respectively, and F = 96,540 coulombs. At infinite dilution (α = unity)

$$\Lambda = l_u + l_v.$$

The ionic conductivity may also be derived as the product of the molar conductivity and transport number. The ionic conductivity of the sodium ion is 43·5, that of the hydrogen ion 314; OH' has the value 174, and NO' 62, all at infinite dilution at 18° C.

Ionic Hypothesis.—The hypothesis that those substances whose solutions conduct the electric current (electrolytes) are split up or dissociated in the solution into ions, and that it is these ions which are instrumental in conducting the current. Since the solution is electrically neutral the total charge of negative electricity on the negative ions (anions) must be equal to the total charge on the positive ions (cations). Every binary electrolyte may be represented as dissociating into two ions. Thus for an acid, $HA=H^{\cdot}+A'$; and for a base, $B.OH=B^{\cdot}+OH'$; and for a salt, $BA=B^{\cdot}+A'$. The hypothesis was first suggested by Clausius in 1857, but was greatly extended and developed by Arrhenius (1884), and later still by Ostwald, van't Hoff, and others. Although the hypothesis is not accepted by some, it is the one which has offered the most satisfactory explanation of the properties of solutions. There are, however, some apparent anomalies which have not yet received satisfactory elucidation. *See* Electrolytic Dissociation, and Ions.

Ionic Mobility.—The speed with which ions move through a solution under the influence of a voltage applied across the solution; *e.g.* for a potential difference of one volt per centimetre the ionic mobility (velocity of migration) at 18° C. of the hydrogen ion is 329×10^{-5}; that for $Na^{\cdot}$ is 45×10^{-5}, for OH', 184×10^{-5}; and for NO_3', 65×10^{-5}, all in centimetres per second. The symbols μ_A and μ_C, or v and u, are usually employed for the ionic mobilities of anion and cation respectively. The ions in an ionised gas also have appreciable velocities. Thus for a potential of one volt per centimetre the positive ions in ionised hydrogen have a velocity of 6·7 centimetres per second, and the negative ions 7·95

Ionic Radius.—Values for the ionic radius may be derived from the diffusion equation of Einstein:—

$$U = \frac{K}{N.6\pi\eta\rho},$$

where U = velocity, ρ = radius, K = the force acting on the ion, N = the Avogadro number, η = viscosity. The value for the radius lies between 2·0 and 3·9, $\times 10^{-8}$ cms. It may also be derived from the formula of Born:—

$$W = \tfrac{1}{2}(1-1/\varepsilon)N.2388 \times 10^{-11}\, e^2z^2/r_i \text{ Cal.},$$

where W = heat of hydration, N = Avogadro number, z = valency, e = electronic charge, ε = dielectric constant of the solvent, and r_i = ionic radius.

Ionic Synergism.—A law for the coagulating power of cations in presence of hydrogen ions; *i.e.* combined power of metal ion + hydrogen

ion in coagulation of hydrosols. The law is expressed by the equation

$$\frac{\log h_0}{h} \times \frac{\log i_0}{i} = K,$$

where h and i are the concentrations of hydrogen ion and cation respectively; h_0 and i_0 the concentrations of these ions which effect coagulation alone, *i.e.* in the absence of the other (*i.e* the true coagulating power). K is a constant depending on the nature of the dispersoid and cation, and on the degree of change of dispersivity effected.

Ionisation Constant.—The dissociation constant of the equilibrium between an electrolyte and its ions in solution; *e.g.* for acetic acid at 25°

$$\frac{[CH_3COO'] \times [H^{\cdot}]}{[CH_3COOH]} = K = 0.000018.$$

The square brackets indicate concentrations, usually in gram-molecules (or gram-ions) per litre. *See* Electrolytic Dissociation, Dilution Law, and Mass Action, Law of.

Ionisation (Electrolytic).—The formation of ions in solution. *See* Ions.

Ionisation (Gaseous).—The formation of ions in gases. *See* Ions.

Ionisation Isomerism.—*See* Isomerism, Ionisation.

Ionisation Potential.—The minimum voltage required to produce ionisation in a gas. For hydrogen the potential is 11 volts, and for nitrogen 7·5 volts.

Ionogenic Combination.—A state of combination of an atom or group in a molecule by virtue of which it dissociates in solution to give the corresponding ion.

Ionogens.—Atoms or groups which are ionisable; *e.g.* the hydrogen atom in the aldehyde group —CHO is not an ionogen, but that in the carboxyl group —COOH, is.

Ionometer.—A special conductivity apparatus for determining the electrical conductivity of serum, urine, etc., in clinical work. The term is really a trade name for this particular apparatus.

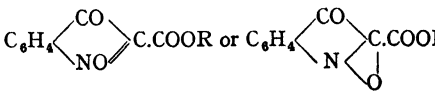
Ions.—A name given by Faraday to those atoms or particles in solution which carry the electric current during electrolysis. They are now recognised as being atoms or groups carrying electric charges. These charges are not derived from the current, the ions being already present as such before the passage of the current. They are formed immediately the electrolyte is dissolved and are produced by the electrolytic dissociation (*q.v.*) of the electrolyte. The electrical charges are denoted by $^{\cdot}$ or $^{+}$ for the positively charged ions (cations) and by $'$ or $^{-}$ for the negatively charged, or anions. Thus for hydrochloric acid the ions are $H^{\cdot}$ and Cl', or H^{+} and Cl^{-}. The number of charges corresponds to the valency of the atom or group; *e.g.* sulphuric acid, H_2SO_4, gives $2H^{\cdot} + SO_4''$; $Fe_2(SO_4)_3$ gives the ions $Fe^{\cdot\cdot\cdot}$ and SO_4''; and so on. The ions are formed by the gain or loss of electrons. Thus the hydrogen atom loses one electron (*i.e.* one negative charge) and so acquires one positive charge, becoming the ion H^{+}; the chlorine atom gains one electron and so acquires one negative charge, becoming the ion Cl^{-}; an atom of (ferric) iron loses three electrons and so becomes the ion Fe^{+++}; and so on. All acids furnish hydrogen ions, and the bases hydroxyl ions, OH'. Some of the commoner ions are $H^{\cdot}$, $K^{\cdot}$, $Na^{\cdot}$, $Ca^{\cdot\cdot}$, $Pb^{\cdot\cdot}$, $Cu^{\cdot\cdot}$, $Fe^{\cdot\cdot}$, and $NH^{\cdot}_4$ (cations); and Cl', Br', NO_3', SO_4'', CH_3COO', and CO_3'' (anions). There are also what are termed *complex ions*, which are produced from complex salts or molecular compounds, or by combination of an ion with undissociated molecule or molecule of solvent (*see* Hydrols); *e.g.* iodine in KI solution gives the complex ion I_3'; potassium cyanide and silver cyanide give the complex argenticyanide ion $Ag(CN)_2'$.

Ions may also be produced in a gas when the latter is subjected to the action of certain radiations (*e.g.* X-rays or cathode rays) or an electric field. Under these conditions the gas becomes electrically conducting, *gaseous ions* being produced. These, however, do not persist when the radiations, etc., are removed. *See* Electrolytic Dissociation, and Electrons.

Irreversible Cell.—An electrolytic cell which, after working and delivering current, cannot be restored to its original condition by sending through it from an outside source a current in the reverse direction.

Irritants.—Drugs which, taken internally or applied locally to the skin, dilate the blood vessels and increase secretion.

Isatogens.—Compounds having the structure



Other formulæ have been proposed.

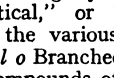
Isatoids.—Compounds derived from the con-

densation of one molecule of isatin with one of an isatin alkyl ether.

Isentropic.—Involving no change of entropy. Clausius introduced the term in connection with systems undergoing adiabatic change. There is no change of entropy in an adiabatic change of state.

Iso-.—A prefix signifying "the same," "equal," "identical," or "constant." *See* following under the various terms beginning with iso-. *See al o* Branched Chains.

Iso-amides.—Compounds of the type



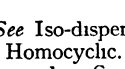
Isomeric form of the amides, $R\,CONH_2$. Also termed *iminohydrins*

Isochore (van't Hoff).—*See* van't Hoff Isochore.

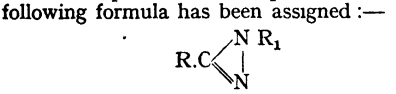
Iso-colloids.—*See* Iso-dispersoids.

Isocyclic.—*See* Homocyclic.

Isodiazo Compounds.—Compounds isomeric with the aliphatic diazo compounds to which the following formula has been assigned :—



Isodizotates.—Compounds isomeric with the diazotates (*q v.*). According to Hantzsch they are stereoisomers similar to the syn- and anti-forms of the oximes; *e.g.* potassium benzene-diazotate :—



$C_6H_5.N$	$C_6H_5.N$
KO N	N OK
Diazotate	Isodiazotate

Bamberger considers them to be structural isomers :—

$C_6H_5N{=}N.OK$	$C_6H_5NK{-}NO$
Diazotate	Isodiazotate

Isodimorphism.—*See* Isodimorphous.

Isodimorphous.—Two dimorphous substances which are also isomorphous in both crystalline forms are said to be isodimorphous or to exhibit *isodimorphism.*

Isodispersoids.—A disperse system consisting of one substance; *i.e.* the substance forms both disperse phase and dispersion medium; *e g.* petroleum and many waxes and higher fatty acids when molten.

Isodynamic.—A term sometimes applied to dynamic isomers. *See* Allelotropism, and Isomerism, Dynamic.

Isoelectric Point.—By addition of certain electrolytes (*i.e.* ions) to a dispersoid a concentration of the former is reached at which the dispersoid becomes electrically neutral owing to the ions of opposite charge to the dispersoic giving up their charges to the dispersoid; *i.e* the charge on the dispersoid is neutralised by that on the ion. At this point—termed by Hardy the isoelectric point—coagulation occurs (in absence of disturbing factors), and in cataphoresis the velocity becomes zero; *e g* for a silver hydrosol the isoelectric point is reached by the addition of $Al_2(SO_4)_3$ when the solution contains 26×10^{-5} grams of Al ions per litre.

Isogonous—*See* Isomorphous.

Isohydric Solutions.—Any two solutions which, when mixed, show no alteration in the concentration of the ions. If two solutions have a common ion in the same concentration in both no change in the concentration o this ion will occur when the two solutions are mixed.

Isologous.—A term occasionally employed fo those series of compounds which are allied chemically but between the members of which there is a difference in composition other than CH_2 (distinction from homologous series); *e.g* the benzene-naphthalene-anthracene series. *Se* Allologic Series, and Homologous Series.

Isomeric.—*See* Isomerism.

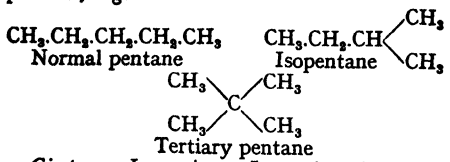
Isomerides.—*See* Isomerism.

Isomerisation.—The conversion of a compound into an isomer. *See* Molecular Transposition; Isomerism, Keto-enol and Cis-trans Hofmann Reaction; Benzidine, and Semidin Transpositions, for examples.

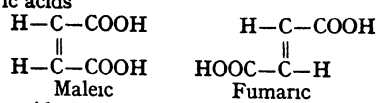
Isomerism.—There are a large number o cases in organic chemistry in which two or more compounds have the same composition (*i.e.* they are represented by the same molecular formula but differ to a greater or less extent in physical and in many cases chemical, properties. Such compounds are said to be *isomeric,* and are termed *isomers* or *isomerides.* The relationship is termed *isomerism*; *e.g.* there are two distinct compounds having the formula C_4H_{10}, and five having the composition C_6H_{14}. Cases of isomerism also occur in inorganic chemistry; *e.g* in the case of the metal ammines. A number of special types of isomerism have been recognised and these have been given special names They are as follow :—

Chain Isomerism.—Isomerism due to the difference in arrangement of the carbon atom

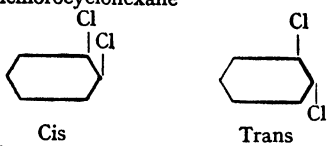
in the skeleton or chain of the acyclic compounds; *e.g.*



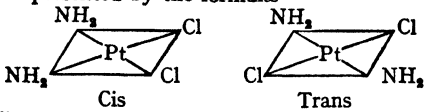
Cis-trans Isomerism.—Isomerism due to the relative positions of two groups with respect to each other; *e.g.* in the case of maleic and fumaric acids



Maleic acid is termed the *cis* or *maleinoid* form. The two COOH groups are together or on the same side of the molecule. Fumaric acid is the *trans* or *fumaroid* form, the COOH groups being apart or on opposite sides of the molecule. Another example of this kind of isomerism is furnished by the substituted hydroaromatic compounds. The ring atoms are regarded as in a plane and the substituents are in another plane either above or below this plane; *e.g.* 1, 2-dichlorocyclohexane

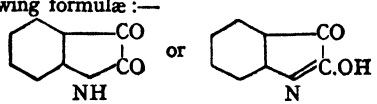


Certain cases of isomerism among the metal ammines also fall into this class; *e.g.* dichloroplatindiammine, $PtCl_2(NH_2)_2$, whose isomerism is represented by the formulæ



The conversion of a cis isomer into a trans, or *vice versa*, is sometimes termed inversion.

Dynamic Isomerism.—This term includes that type of isomerism in which a compound can react as if it possessed two different and distinct constitutions; *e.g.* certain reactions of isatin show that it may have either of the following formulæ:—



Another example is that of acetoacetic ester. The difference in both these cases is explained by the wandering of a hydrogen atom from one atom to another, thus:—

$$-CO-NH- \rightleftharpoons -C(OH)=N-$$
$$-CO-CH< \rightleftharpoons -C(OH)=C<$$

Van Laar explained the phenomenon by assuming that the hydrogen atom was continually moving or oscillating from one atom to the other. He termed the phenomenon *Tautomerism.* The two isomers (*tautomers*) have, however, in many cases been isolated. Jacobson introduced the term *Desmotropism* (*Desmotropy*), and Claisen suggested the term *Pseudomerism.* The term tautomerism, although it has lost the original meaning given to it by Laar, is still largely used to denote that a compound can react in two different ways, and desmotropy is employed to denote that there is a definite molecular transposition within the molecule. *See* Allelotropism.

Geometrical Isomerism.—This is a special case of stereoisomerism due to the different spatial arrangement of certain atoms or groups which are attached to different carbon atoms which are joined by a double bond; *e.g.* in the case of ethylenic compounds of the type R.CH = CH.R, the two isomers are represented by the plane formulæ

This type of isomerism is also termed *Ethylenic Isomerism.* The isomerism of the oximes is similar. *See* Oximes.

Ionisation Isomerism.—The formation of isomers by the rearrangement of groups which have been ionised; *i.e.* the compound dissociates into ions, one of which then attaches itself to another part of the molecule as a non-ionisable group. *E.g.* the basic hydroxide of aminotriphenylmethane, $(C_6H_5)_2C = C_6H_4 = NH_2OH$, in which the OH group ionises and then migrates to the methane carbon atom to give the undissociable carbinol,

$$(C_6H_5)_2C(OH).C_6H_5NH_2.$$

The term is also applied to those isomers of the ammines in which an atom or group is ionisable in one but not in the other. *E.g.*

$[Pt(NH_3)_4Br_2]Cl_2$ and
$[Pt(NH_3)_4Cl_2]Br_2$.

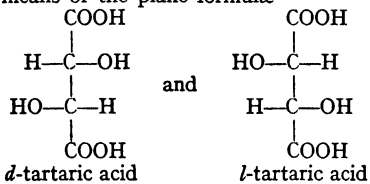
See Ammines. Cf. Valency Isomerism.
See also Hydrocarbo Bases.

Keto-enol Isomerism.—Isomerism of the type $-CH_2-CO- \rightleftharpoons -CH=C(OH)-$. A keto group CO becomes a tertiary alcohol group; *e.g.* acetoacetic ester

$CH_3COCH_2COOC_2H_5 \rightleftharpoons CH_3C(OH):CHCOOC_2H_5$.
Keto Enol

The enolic isomers are sometimes referred to as enolic compounds.

Optical Isomerism.—A type of stereoisomerism. A compound containing one or more asymmetric carbon (or other) atoms exists in two stereoisomeric forms, both optically active (*see* Asymmetry, Molecular). The rotatory powers are equal and opposite (*see* Optical Activity). The isomers are otherwise identical in chemical and most physical properties (*see* Enantiomorphs); *e.g.* dextro-tartaric acid, ($[\alpha]_D = +14°$), and lævo-tartaric acid, ($[\alpha]_D = -14°$). Their isomerism may be represented by means of the plane formulæ

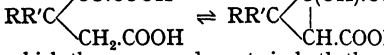


d-tartaric acid *l*-tartaric acid

Further examples are furnished by the sugars. *See* Internal Compensation.

Position (or *Place*) *Isomerism.*—Isomerism due to one or more atoms or groups occupying a different place in the nucleus; *e.g.* ortho and para nitrotoluenes, and the ortho, meta, and para positions generally in the aromatic compounds. The term usually only applies to isomers which are more or less closely allied chemically. *Cf.* Structural Isomerism.

Ring-Chain Isomerism (*Tautomerism*).—(1) Isomerism existing between a cyclic compound and the corresponding acyclic compound; *e.g.* trimethylene and propylene. (2) Tautomerism in compounds of the type



in which the compound reacts in both the cyclic and open chain forms. R, R' are alkyl radicals; *e.g.* ethyl.

Stereoisomerism.—Isomerism due to the different spatial arrangement of certain groups. The isomers are termed *stereoisomers*. They possess the same constitution and structure but differ in the manner in which the atoms and groups are distributed in space. Geometrical, Cis-trans, and Optical Isomerism are cases of stereoisomerism. *Cf.* Position Isomerism.

Structural Isomerism.—The isomers of this type of isomerism are distinguished by a difference in the structure of the molecule, often attributed to a difference in the position of some functional grouping, this difference resulting in most cases in a marked difference of properties; *e.g.* ethyl nitrite, $C_2H_5.O.NO$, and nitroethane, $C_2H_5.NO_2$; benzidine and *pp'*-diaminodiphenyl, etc.

Valency Isomerism—A name suggested by Werner for certain cases of isomerism in the complex inorganic salts. The isomerism, according to Werner's theory, is due to a group or atom being attached by a principal valency in one isomer and by an auxiliary valency in the other.

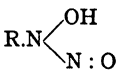
Isomers.—*See* Isomerism.

Isometric.—*See* Cubic System (Crystal).

Isomorphism.—*See* Isomorphous.

Isomorphous.—Two substances which crystallise in the same system are said to be isomorphous with one another, or to exhibit *isomorphism*. If the two substances differ in chemical properties, i.e. belong to different classes, they are sometimes called *isogonous*. *See* Mitscherlich, Law of; and Mixed Crystals.

Isonitramines.—Compounds isomeric with the nitramines to which the following formula has been ascribed:—

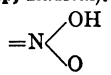


e.g. isonitramine-acetic acid,

$HOOC.CH_2\,N(OH)\,NO$.

Isonitriles.—Compounds of the formula $R.N = C$. Also termed carbylamines or isocyanides; *e.g.* $CH_3N : C$. *See* Nitriles.

Isonitro- (Group, Radical).—The group



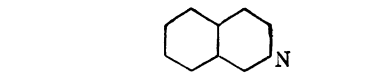
Also termed *aci-nitro*. Phenylisonitromethane, $C_6H_5CH : NO.OH$, is an example of an isonitro compound.

Isonitroso Compounds.—Compounds containing the group $>C = N.OH$. The name is given to those compounds which are obtained by the action of nitrous acid on a methylene group; *e.g.* isonitrosoacetone, $CH_3COCH : NOH$. The group is identical with the oxime group. Thus the above compound is the same as the oxime of pyruvic aldehyde, CH_3COCHO. The term is

used to distinguish the mode of formation of the compound. *See* Oximes.

Isonitroso Group.—The group =N.OH. Also termed the *oximino* group. *See* above.

Iso-oximes.—Lactams produced by the intramolecular rearrangement of cyclic ketoximes; *e.g.*



Ketoxime Iso-oxime

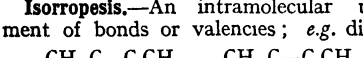
Isopiestic.—At the same or constant pressure.

Isopropenyl (Radical).—The group $CH_3.C(.CH_2)-$.

Isoquinolines.—Derivatives of isoquinoline :—

Some of the alkaloids (narcotine, papaverine, etc.) are important isoquinoline derivatives.

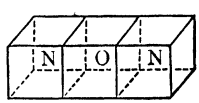
Isorropesis.—An intramolecular rearrangement of bonds or valencies; *e.g.* diacetyl :—



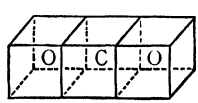
The idea of this rearrangement was put forward by Baly and Stewart to account for selective absorption. *Cf.* Isomerisation, and Molecular Transposition.

Isosmotic.—Having the same osmotic pressure. *See* Isotonic.

Isosteric Compounds.—Compounds having the same number of atoms in the molecule and the same number of electrons arranged in the same manner (Langmuir); *e.g.* nitrous oxide and carbon dioxide are isosteric :—



Number of external electrons in
$N_2O = (2 \times 5) + 6 = 16$



Number of external electrons in
$CO_2 = (2 \times 6) + 4 = 16$

Isotherm (van't Hoff).—*See* van't Hoff Isotherm.

Isothermal (Process).—A process taking place at constant temperature. *Cf.* Adiabatic (Process).

Isothiocyanic Esters.—Esters of the unknown isothiocyanic acid H.N : C : S; *e.g.* ethyl isothiocyanate, $C_2H_5N : C : S$. These esters are also known as mustard oils.

Isotonic Coefficient.—A term introduced by de Vries in connection with the plasmolysis of cells by solutions. If a given molar concentration of sugar in aqueous solution is just sufficient to produce plasmolysis, then the molar concentration of a salt solution required to produce plasmolysis is lower, owing to electrolytic dissociation. The ratio of the molar concentration of the salt to that of the sugar to which it is plasmolytically equivalent is termed the isotonic coefficient of the salt.

Isotonic Solutions.—A solution is said to be isotonic with a given kind of cell (or blood corpuscles) when these cells neither shrink nor swell when immersed in the solution. If they shrink (*i.e.* part with water) the solution is said to be *hypertonic*; if they swell (*i.e.* take up water) the solution is *hypotonic*. The term *isotonic* is frequently employed to denote that two solutions have the same osmotic pressure. The first case given above is an example.

Isotopes.—Elements of different atomic weights but so closely allied in chemical and physical properties that they are inseparable by the ordinary methods and therefore appear to occupy the same position in the Periodic Classification of the elements. The atomic weights differ, in fact, by very small amounts. From the point of view of the modern theory of atomic structure they must have atomic nuclei of different masses, and different numbers of electrons, but their nuclear charges are equal and so are the number of electrons in the external or outer zone. Elements whose atomic weights are not whole numbers (o = 16) are probably all mixtures of isotopes; *e.g.* neon (at. wt. = 20·2) is a mixture of isotopes of atomic weights 20 and 22. The relationship is termed *isotopy*. *See* Positive Ray Analysis.

Isotopy.—*See* Isotopes.

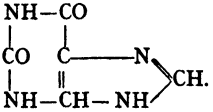
Isotrimorphous.—Two substances are isotrimorphous when each crystallises in the same three crystalline forms. Stannic and titanic oxides furnish an example.

Isotropic.—*See* Isotropy.

Isotropy.—Substances showing the same properties in all directions are said to be *isotropic* or to exhibit isotropy. The property is

characteristic of amorphous substances. *Cf.* Anisotropy.

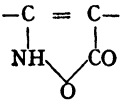
Isoxanthines.—Derivatives of isoxanthine :—



They have the double bond in the iminazole ring in the 7, 8 position instead of the 8, 9 position as in xanthine. *See* Xanthine Bases.

Isoxazoles.—*See* Azoles.

Isoxazolones.—Compounds containing the nucleus



J

Joule.—A unit of work or energy. 1 Joule = 10^7 ergs or 1 volt-coulomb. It is also equal to 0·2382 calories, or 1 calorie = $4{\cdot}19 \times 10^7$ ergs = 4·19 Joules. This is known as *Joule's Equivalent* or the *Mechanical Equivalent of Heat.* It is given by the equation

$$W = JQ,$$

where W = work and Q = heat. This is one expression for the First Law of Thermodynamics.

Joule's Law.—There are two laws which are often referred to as those of Joule, viz. (1) the internal energy of a given mass of gas is independent of the temperature. This is only true of ideal gases. (2) The molecular heat of a compound is approximately the sum of the atomic heats of the atoms contained in it. Kopp modified this to "an element has the same atomic heat whether free or combined."

Joule-Thomson Effect.—If a mass of gas having a volume v and pressure p be forced through a small orifice or porous plug so that its volume is now v_1 and pressure p_1, then, if the gas obeys Boyle's Law,

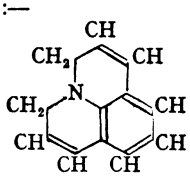
$$pv = p_1v_1.$$

There should be no change in temperature, since the work done in forcing the gas through the orifice or plug is equal to that done by the gas in expanding against the pressure p_1. Joule and Thomson in their famous "porous plug experiment" found that most gases were cooled, but hydrogen was warmed. They also found that the change in temperature was proportional to the difference in pressure; *i.e.*

$$T - T_1 = K(p - p_1).$$

The fall in temperature is due to the *internal* work done in overcoming molecular attraction. Below −80° C. hydrogen is also cooled. The point at which the temperature changes sign is termed the inversion point. At this point K is zero.

Juloles.—Derivatives of the at present unknown julole :—



Julolidines.—Tetrahydrojuloles, reduction being in the heterocyclic rings.

Julolines.—Dihydrojuloles, reduction being in one of the heterocyclic rings.

K

Kal.—*See* Calorie.

Katabolism.—Catabolism (*q.v.*).

Kataphoresis.—Cataphoresis (*q.v.*).

Kations.—Cations (*q v*).

Keller's Test.—For the detection of digitalin glucosides. The substance is dissolved in 1 c.c. of a solution of 100 c.cs. glacial acetic acid and 1 c.c. of 5 per cent ferric sulphate. The solution is treated with 2 c.cs. of a solution of 100 c.cs. concentrated sulphuric acid and 1 c.c. of 5 per cent ferric sulphate. Digitoxin gives a blue colour in the acetic acid layer and digitalin a cherry red in the sulphuric acid.

Kerr Constant.—*See* Electrical Birefringence.

Ketazines.—Compounds having the general formula

$$R_1R_2.C = N.N = C.R_1R_2,$$

where R_1, R_2 are alkyl or aryl radicals. They are formed by the condensation of two molecules of a ketone R_1COR_2 with one molecule of hydrazine, $H_2N.NH_2$; *e.g.* acetone yields the ketazine $(CH_3)_2C : N.N : C(CH_3)_2$. *Cf.* Aldazines.

Ketenes.—Compounds having the general formula $R_1R_2C = CO$. Ketene itself is $CH_2 : CO$, and is the parent compound of the class. Monosubstituted ketenes, R.CH : CO, are termed *aldoketenes* and the disubstituted, $R_1R_2C : CO$, *ketoketenes.*

Ketenium Compounds.—Derivatives of ketene of the type

$$R_1R_2C = C{-}O \rightarrow N(R)_3$$

where $(R)_3$ are three alkyl radicals, *e.g.* ethyl.

Ketimides.—Compounds having the general formula

$$R_1{-}C(=N.X){-}R_2$$

where X is an acyl radical such as acetyl, benzoyl, etc.

Ketimines.—Compounds having the general formula

$$R_1{-}C(=NH){-}R_2$$

They are derivatives of the ketones in which the ketonic oxygen has been replaced by the imino group; *e.g.* $(CH_3)_2N\,C_6H_4.C(NH)\,C_6H_4.N(CH_3)_2$, the dyestuff auramine. *Cf.* Aldimines. *See* Imines.

Keto-.—A prefix denoting the presence in the molecule of one or more keto- groups, >C.CO.C<. *See* Ketones.

Keto-bases.—Compounds containing a keto and amino group; *e g* $C_6H_5COCH_2CH_2N(CH_3)_2$, ω-dimethylaminopropiophenone.

Keto-enol Isomerism.—*See* Isomerism, Keto-enol.

Ketols.—Keto-alcohols; *i.e.* compounds containing both a keto group and an alcoholic OH group; *e.g.* CH_3COCH_2OH. *See* Acyloins.

Ketones.—Compounds containing the grouping >C—CO—C< (the keto group); *e.g* acetone (dimethyl ketone), CH_3COCH_3; acetophenone (phenylmethyl ketone), $C_6H_5COCH_3$. Ketones containing one keto group are termed *monoketones* and are *simple* when they have the same radical on each side of the CO, as in acetone (above), and *mixed* when these two radicals are different, as in acetophenone (above). Ketones containing two CO groups are termed *diketones* and are classed as α-, β-, γ-, etc., according as the two CO groups are directly linked or are separated by one, two, etc., carbon atoms; *e.g.* diacetyl, $CH_3COCOCH_3$ (α-diketone); acetylacetone, $CH_3COCH_2COCH_3$ (β-diketone); acetonylacetone, $CH_3COCH_2CH_2COCH_3$ (γ-diketone). The CO groups may form part of a ring giving a *cyclic ketone*; *e.g.* cyclohexanone. (*See also* Pyrones, Pyrazolones, Indolenones.) *Cf.* Aldehydes. *See* Geneva Nomenclature.

Ketonic Acids.—Carboxylic acids containing one or more keto groups; *e.g.* pyruvic acid, $CH_3COCOOH$ (α-ketonic acid); acetoacetic acid, CH_3COCH_2COOH (β-ketonic-acid).

Ketonic Esters.—Esters of ketonic acids (*q.v.*).

Ketoses.—A name given to those members of the carbohydrates (sugars) which contain a keto group; *e.g.* fructose. *See* Sugars.

Ketosides.—*See* Glucosides.

Ketosis.—A term employed in connection with urine analysis to denote the presence of ketones or ketonic acids.

Ketoxido- Compounds.—Compounds formed by the action of alkaline hydrogen peroxide on the αβ-unsaturated ketones; *e.g.* benzalacetone, $C_6H_5CH.CHCOCH_3$, yields a compound having one more atoms of oxygen. These ketoxido-compounds probably contain the grouping

$$>C{-}C(=O){-}CO-$$

Ketoximes.—*See* Oximes.

Ketyls.—*See* Metal-ketyls.

Key Atom.—*See* Induced Alternate Polarity.

Kilogram-Calorie.—*See* Calorie.

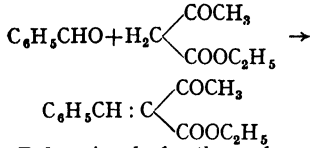
Kishner-Wolff Reduction Method.—A method for reducing the CO group to CH_2, especially in cyclic ketones. The compound is treated with hydrazine or semicarbazide, and the resulting hydrazone or semicarbazone is heated to 150–200° with dry sodium ethoxide. Benzophenone, $C_6H_5.CO.C_6H_5$, gives in this way diphenylmethane, $C_6H_5.CH_2.C_6H_5$.

Kjeldahl Method.—A method for estimating nitrogen in organic compounds. The substance is heated with concentrated sulphuric acid, a little anhydrous potassium sulphate being added to raise the boiling point. The nitrogen is converted into ammonia (ammonium sulphate). The liquid is made alkaline with sodium hydroxide and distilled. The liberated ammonia is absorbed in standard acid and estimated by titration. The method is not satisfactory for compounds containing the nitro, nitroso, azo, or hydrazo groups.

Knapp's Solution.—A solution of potassium mercuricyanide. Employed in glucose estimations.

Knoevenagel's Reaction.—The condensation of aldehydes and ketones with 1 : 3-diketones or ketonic esters in presence of organic bases such as diethylamine, aniline, etc.; *e.g.* benzaldehyde

and acetoacetic ester give benzalacetoacetic ester:



Kopp's Rule.—A rule for the molar volumes of liquids at the boiling point, viz. that chemically related compounds show the same difference in molar volume for the same difference in composition. *E.g.* the molar volume of formic acid is 42, acetic acid 64, propionic acid 86, and butyric acid 108. There is a constant difference of 22 for each difference in composition of CH_2. Isomeric compounds have the same molar volume, and the value of the latter is not changed by replacing one oxygen by two hydrogens or two hydrogens by one oxygen. Further, the molar volume is the sum of the atomic volumes *See also* Joule's Law.

K-radiations.—A series of characteristic X-rays emitted by metals when subjected to the action of cathode rays, the metal constituting the anticathode. The frequency of these radiations is proportional to the square of the atomic number. For silver the K-radiation has a wave length of $0{\cdot}56 \times 10^{-8}$ cms.

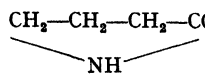
Kundt's Rule.—In the absorption of light by a solution, the absorption is affected in such a way that the absorption bands are shifted towards the red with increase in refractive index. *See* Beer's Law.

L

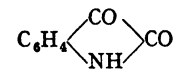
L-, l-.—*See* Table of Symbols, p. 157.

Lachrymators.—Tear-producing gases, such as the halogens and certain organic halogen compounds.

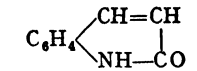
Lactams.—Cyclic compounds containing the —NH—CO— grouping. They are formed from β- or γ- aminoacids by elimination of one molecule of water from the NH_2 and COOH groups; *e.g.* γ-aminobutyric acid, $NH_2CH_2CH_2CH_2COOH$, gives γ-butyrolactam:—



They may therefore be regarded as internal amides. Other examples of a somewhat different type are the lactam tautomers of isatin and carbostyril:—



Lactam isatin

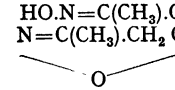


Lactam carbostyril

Cf. Lactims.

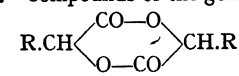
Lactazams.—Pyrazolones (*q.v.*).

Lactazones.—Isoxazolones (*q.v.*), or lactoximes. They are formed, *e.g.*, by elimination of one molecule of alcohol from the oximes of β-ketonic esters:—



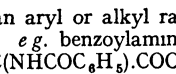
Lactic Fermentation.—*See* Fermentation.

Lactides.—Compounds of the general formula

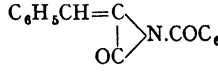


formed by condensation of two molecules of α-hydroxyacid, R.CH(OH)COOH, with elimination of two molecules of water. *Cf.* Lactones.

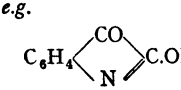
Lactimides.—Internal aminic anhydrides of the general formula



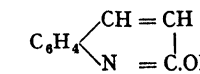
where R is an aryl or alkyl radical and X an acyl radical; *e.g.* benzoylaminocinnamic acid, $C_6H_5CH=C(NHCOC_6H_5).COOH$, gives benzoylaminocinnamic lactimide,



Lactims.—Compounds containing the grouping $-N=C(OH)-$. This grouping is tautomeric with the lactam —NH—CO— grouping; *e.g.*



Lactim isatin



Lactim carbostyril

See Lactams, and Isomerism, Dynamic.

Lactochromes.—The yellow pigments of butter fat.

Lactones.—Cyclic compounds produced from hydroxyacids by internal condensation between the hydroxy and carboxyl groups with elimination of one molecule of water. They may therefore be regarded as internal esters; *e.g.*

γ-hydroxybutyric acid yields γ-butyrolactone,

Only the lactones of γ- and δ-hydroxyacids are formed readily. The process is termed *lactonisation*.

Lactonisation.—*See* Lactones.

Lactoximes.—*See* Lactazones.

Lactyl- (Radical).—The group

$$CH_3.CH(OH).CO—.$$

The radical of lactic acid.

Lævogyrate.—Lævorotatory. *See* Optical Activity.

Lævorotatory.—*See* Optical Activity.

Lakes.—Compounds of certain dyestuffs with metallic oxides, such as, *e.g.*, those of alizarin with the oxides of aluminium, iron, barium, and chromium.

Landolt-Oudemans' Law.—The salts of optically active acids and bases give a constant value for the optical rotation in dilute solution; *i.e.* the rotation is independent of the inactive ion present.

Lange's Colloidal Gold Test.—A test with colloidal gold carried out on the cerebrospinal fluid in testing for syphilis and similar diseases.

Lassaigne's Test.—A test for nitrogen and halogens in organic compounds. The substance is heated with metallic sodium or potassium, the mass treated with hot water and filtered. To one portion of the filtrate is added a few drops of ferrous sulphate solution and then hydrochloric acid and the solution warmed. Ferric chloride is then added. A blue precipitate (Prussian Blue) indicates nitrogen For halogens another portion of the filtrate is acidified with nitric acid and boiled (to expel HCN if N is present). The solution is then tested with $AgNO_3$ in the usual way.

Lattice Constant.—The distance between two planes of atoms in a crystal. It is given by

$$2d \sin \theta = n\lambda,$$

where θ is the angle of incidence of the X-rays on the crystal, λ the wave length, and n an integer (1, 2, 3, . . .) $n\lambda$ is the difference in path or phase of the reflected X-rays for maximum reflection. d is the lattice or grating constant. *See* Space Lattice and X-ray Analysis.

Lattice (Crystal).—*See* Space Lattice.

Laue Diagram.—When a narrow beam of X-rays is passed through a crystal the rays are diffracted and give a symmetrical pattern (*Laue Diagram*) of dark spots (*Laue Spots*) on a photographic plate. This phenomenon is due to the symmetrical configuration of the atoms in the crystal, the crystal thus acting like a diffraction grating. *See* Space Lattice.

Lauryl- (Radical).—The normal group $CH_3(CH_2)_9CO—$. The radical of lauric acid.

Laxatives.—A class of purgatives which act by increasing the contractions of the muscular walls of the intestines; *e.g.* magnesia.

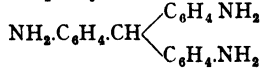
Le Chatelier's Principle (or Theorem).—If a system is in equilibrium and one of the equilibrium factors (temperature, pressure, concentration) be altered, the state of the system will change in such a way as to oppose or counteract the effect of the alteration. *E.g.* if the temperature is increased that reaction will ensue which is accompanied by an absorption of heat and *vice versa* If the pressure is increased the system will change in that direction which produces a diminution of volume. The principle is universally applicable to both physical and chemical equilibria. Van't Hoff's law of mobile equilibrium is a special case of the general principle.

Legal's Test.—For acetoacetic acid in urine. A solution of sodium nitroprusside is added and the solution made alkaline with sodium hydroxide. A red coloration is produced which changes to magenta on acidifying with acetic acid. Acetone may be tested for in the same way.

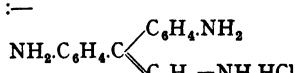
Leptons.—A name suggested for the atoms or molecules in a gram-molecule of a crystalline solid, considered as units, including the space (lepton domain) surrounding them in the crystal structure.

Leuco-.—A prefix meaning "white." It is mainly employed for the colourless or less coloured reduction products of the dyestuffs or their coloured intermediates. *See* Leuco-bases, and Leuco-ethers.

Leuco-bases.—The parent methane derivatives of the triphenylmethane dyestuffs; *e.g.* *p*-triaminotriphenylmethane,



is the leuco-base of the dyestuff rosaniline (magenta):—



Leuco-ethers.—The colourless modifications of the nitrophenol ethers; *e.g.* nitro-anisole. These are the ordinary ethers, the isomeric red

compounds being difficult to prepare. *See* Chromoisomerism.

Leucyl- (Radical).—The group $CH_3CH_2CH_2CH_2CH(NH_2).CO—$. The radical of leucine.

Lewis-Langmuir Theory.—A theory of the structure of the atom. Atoms are composed of a positive nucleus surrounded by concentric shells of electrons which are either fixed relatively to each other and to the nucleus or at least have only a slight vibratory motion about fixed points. Only the outermost shell of electrons is concerned in chemical reactions. The number of electrons in the outer shell may vary from 0 to 8, but the number held tends to be 8 (*i.e.* an octet) in the most stable atoms, and these are arranged at points corresponding to the eight corners of a cube. (This part of the theory is concerned only with the elements of lower atomic weight, from argon downwards. Langmuir suggests different numbers of electrons in the outer shells of the heavier atoms.)

Union of atoms may be of two types, viz (1) *Polar*, in which union is due to electrostatic attraction between an atom which has given up some or all of its outer electrons and so become positively charged, and another atom which has gained electrons and so become negatively charged. (2) *Non-polar*, due to the mutual penetration of the shells of two atoms so that the atoms hold 2, 4, or 6 electrons in common, such unions corresponding to the single, double, and triple bonds of the ordinary valency theory. *See* Isosteric Compounds, and Formulæ (Chemical), Electronic.

Lieben's Test.—The iodoform test for acetone; *i.e.* formation of iodoform by treating with iodine and potassium hydroxide.

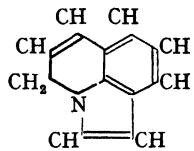
Liebermann's (Nitroso) Reaction.—If a nitrosamine is warmed with concentrated sulphuric acid and a little phenol added, a deep red coloration is produced which changes to blue on pouring into water and making alkaline. Similarly, if a phenol be dissolved in excess of concentrated sulphuric acid and a nitrite or nitrosamine be added, intensely coloured green or blue solutions are obtained.

Liebermann-Kostanecki Rule.—Only those anthraquinones which have two hydroxyl groups ortho to one another will form lakes. There are many exceptions.

Liebermann-Storch Test.—For the detection of rosin oil. The substance is warmed with acetic anhydride. The solution is then withdrawn and a drop of sulphuric acid (sp. gr. 1·53) added. A violet coloration indicates rosin oil.

Liesegang's Rings.—When a drop of silver nitrate solution is placed on a film of gelatin containing ammonium chromate, and the film kept horizontal in a moist atmosphere, the silver nitrate diffuses out from the drop and there are formed concentric annular zones of reaction in which silver chromate is precipitated forming red rings known as Liesegang rings.

Liloles.—Derivatives of the at present unknown lilole:—



Liminal Value.—The minimum concentration of a narcotic (in gram-molecules per litre) which produces a definite physiological effect.

Limit Hydrocarbons.—The saturated acyclic hydrocarbons (the paraffins).

Lin- (Linear).—A prefix employed in naming the polycyclic (fused ring) compounds to denote that the benzene, etc., rings are fused symmetrically to give a straight line of rings. *See, e.g.*, Dinaphthacridines.

Line Spectrum.—*See under* Spectrum.

Ling and Rendles' Indicator.—An aqueous solution of ammonium thiocyanate, ferrous ammonium sulphate, and hydrochloric acid. Used in the estimation of glucose by the copper reduction method.

Lintner Value.—The measure of the diastatic activity of diastase; *i.e.* the amount of hydrolysis of starch to maltose under given conditions.

Lipochromes.—*See* Chromolipoids.

Lipoclastic (Lipolytic) Enzymes.—Enzymes which act by hydrolysing or splitting fats to give glycerol and the fatty acids; *e.g.* lipase. *See* Enzymes.

Lipoids.—A name given by Overton to certain complex organic substances contained in cell protoplasm, particularly that of the nerve tissues. They contain C, H, and O, and some contain N or P, or both, in addition; *e.g.* cholesterol, kerasin, and the cerebrosides, phosphatides, etc.

Liquid Crystals (Crystalline Liquids).—Certain compounds melt to give a cloudy or turbid liquid which, at some higher temperature, becomes quite clear and transparent. *p*-azoxyanisole, *p*-azoxyphenetole, cholesteryl acetate and benzoate, and *p*-methoxycinnamic acid

show this phenomenon. *p*-azoxyanisole melts at 116° to a turbid yellow liquid, and at 135° this changes to a clear liquid. On cooling, the changes are reversed. The turbid liquids, anisotropic liquids, have the optical properties of a uniaxial crystal and have been termed liquid crystals or crystalline liquids.

Liquidus Curve.—In a system of two components which form solid solutions or mixed crystals, the equilibrium between the liquid and solid systems will be represented by two temperature-concentration curves, one for the liquid phase and one for the solid. The former will be the freezing point curve of the liquid (*liquidus curve*) and the latter will be the melting point curve of the solid (*solidus curve*).

Lithontriptics.—Drugs which prevent the formation of urinary calculi.

Litre-atmosphere.—The work done when a gas increases one litre in volume against a pressure of one atmosphere. 1 litre-atmosphere $= 1{\cdot}01 \times 10^7$ ergs, or 24·1 calories.

Lixiviation.—The extraction of a (water) soluble constituent of a solid mixture by mixing and stirring with water and then withdrawing the latter.

Locke's Solution (Ringer-Locke's Solution).—A modified Ringer's solution (*q v.*), designed to suit the isolated mammalian heart by raising the concentration of the salts slightly and by oxygenating it thoroughly. The following is the composition of the solution :—NaCl, 0·9 per cent; KCl, 0·042 per cent; $CaCl_2$, 0·024 per cent; $NaHCO_3$, 0·01–0·03 per cent; glucose, 0·1–0·25 per cent.

Lohnstein's Apparatus.—An apparatus for estimating sugars by fermentation with yeast.

Lorentz and Lorenz Formula.—*See* Specific Refraction.

Loschmidt Number.—*See* Avogadro's Number.

L-radiations.—A series of characteristic X-rays emitted by metals when subjected to cathode rays, the metal forming the anticathode. The frequency of these radiations is proportional to the square of the atomic number of the metal. The wave lengths of the L-radiations are greater than those of the K series. Thus for silver the wave length is $4{\cdot}17 \times 10^{-8}$ cms. *See* K-radiations.

Luminophores.—*See* Fluorophores.

Luteo-.—A prefix given to those cobaltammines having the general formula $Co(NH_3)_6X_3$ or $Co_2(NH_3)_{12}X_6$, where X_6 = six univalent acid radicals or their equivalent; *e.g.* luteocobaltic chloride, $Co(NH_3)_6Cl_3$.

Lutidines.—The dimethyl pyridines.

Lyophile.—A name given to those colloid systems (Liquid + Liquid, or Emulsoid) in which there is a marked affinity between the two phases, dispersoid and dispersion medium. Where the latter is water the term *hydrophile* is used

Lyophobe.—A term applied to those disperse systems (Solid + Liquid, or Suspensoid) in which there is no marked affinity between the disperse phase and dispersion medium. Where the latter is water the term *hydrophobe* is used.

Lyotropic Phenomena.—That class of changes in solutions or colloidal (disperse) systems which depend on changes produced in the medium or solvent. The Hofmeister Series (*q.v.*) is an example of lyotropic influence, the action of the various salts being to change the distribution of the water between the disperse phase and the dispersion medium. Such a series as that of Hofmeister is termed a *lyotropic series.*

Lyotropic Series.—*See* Lyotropic Phenomena.

M

m —*See* Meta-.

$\mathbf{M_D}$.—*See* Molecular Refraction.

Macrochemistry.—The chemistry of substances *en masse* as distinct from the chemistry of atoms and molecules; or *molar* as distinct from *molecular*. *See* Meta-chemistry.

Magnesyl-.—A prefix sometimes employed for the radical —Mg.X in the Grignard reagents (*q v.*), where X is a halogen; *e.g.* magnesylamine, $H_2N.Mg\,Br$(or I).

Magnetic Birefringence.—Double refraction of light exhibited by a substance when subjected to the influence of a magnetic field. *Cf.* Electrical Birefringence.

Magnetic Rotation.—The rotation of the plane of polarised light by a substance under the influence of a magnetic field. The optical effect persists only so long as the field is maintained, and is proportional to the length of substance traversed by the light and to the strength of the magnetic field. The temperature coefficient is small and the rotation depends on the wave length of light used, increasing with decrease of wave length. The sign of rotation is reversed if the magnetic poles are reversed. The *specific magnetic rotation* is given by

$$[\omega] = \frac{a}{d}$$

where *a* is the angle of rotation and *d* the

density of the liquid. If the substance is in solution the value for the solvent must be deducted. Since the values are comparative, water is taken as the standard, the values obtained being compared with that for water under the same conditions. The atomic and molecular rotations are obtained by multiplying the specific rotation by the atomic or molecular weight. Since the molecular rotation of water is not unity (18 × specific rotation), the former values must be divided by the latter to give the true molecular rotation. The property is both additive and constitutive. *See* Optical Activity.

Magnetochemistry.—That branch of physical chemistry which deals with the relationship between magnetic properties—such as magnetic rotation (*q.v.*) and specific magnetisation (*q v*) and chemical constitution.

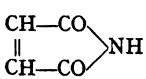
Magneton Theory.—A theory of the structure of the atom somewhat similar to the electron theory but postulating the existence of magnetons instead of electrons These magnetons are rings of negative electricity having a rotating or revolving motion, the velocity being of the order of that of light The atoms tend to form an octet of magnetons, just as in the octet theory of Lewis-Langmuir (*q v.*). The magneton theory has been developed by Parson, Webster, Weiss, and others.

Magnetostriction.—Contraction in volume under the influence of a magnetic field. *Cf.* Electrostriction.

Magnus' Rule.—If a solution of two metallic salts be electrolysed there will be a definite voltage at which only one of the metals will be deposited. *See* Electrolysis.

"Malakograph."—An apparatus for measuring the rate of softening of waxes, resins, etc. A metal ball attached to one arm of a balance is embedded in the solid material and a heavier counterweight is attached to the other arm of the balance. The substance is slowly heated, and as it melts and softens the counterweight slowly falls. A movable pen is attached which traces out a curve on a chart.

Maleinimides.—Derivatives of maleinimide:—



Maleinoid—(Maleoid).—*See* Isomerism, Cis-trans.

Malonyl- (Radical).—The bivalent group —$CO.CH_2.CO$—. The radical of malonic acid.

Mannans.—Anhydrosugars of mannose which yield that sugar on hydrolysis. *See* Hemicelluloses.

Mannosans.—Mannans (*q.v.*).

Markownikow's Rule.—In the addition of halogen acids to ethylenic double bonds, the halogen goes to that carbon atom to which the fewer hydrogen atoms are attached; *e.g.*

$$CH_2 \cdot CH.CH_3 + HI \rightarrow CH_3CHI.CH_3.$$

Also if the olefine is already halogenated the new halogen goes to the carbon atom to which the halogen is already attached; *e.g.*

$$CH_2 : CHBr + HBr \rightarrow CH_3\,CHBr_2.$$

Marsh Test.—A test for arsenic (and antimony). The substance is introduced into a vessel containing zinc and sulphuric acid. Arsine (AsH_3) is produced, which, if passed through a heated tube, gives a black, mirror-like deposit of arsenic. Antimony behaves in a similar manner. The two may be distinguished by treating the deposit with sodium hypochlorite. The arsenic is dissolved but antimony remains unchanged. The original apparatus has been improved by Thorpe, who generates the hydrogen by electrolysis. Minute traces of arsenic may be detected and estimated by this method.

Mass Action, Law of.—The rate at which a chemical reaction proceeds is proportional to the active masses of the reacting substances. By the term *active mass* is meant the molecular concentration; *i e.* the number of molecules in unit volume. In practice, active mass is usually expressed in gram-molecules per litre, and in gaseous reactions as partial pressures, since the partial pressure of a gas is proportional to the number of molecules in a given volume. In a simple reaction

$$A + B \rightleftharpoons C + D$$

the velocity of the forward reaction $A + B$ will be proportional to the concentration of A and also that of B, and hence will be proportional to the product of these concentrations. Thus

$$\overrightarrow{A + B} \propto C_A \times C_B = k_1.C_A \times C_B,$$

where C_A and C_B are the concentrations of A and B and k_1 is a proportionality factor. (*See* Reaction Velocity). Similarly,

$$\overleftarrow{C + D} \propto C_C \times C_D = k_2.C_C \times C_D.$$

At equilibrium the two velocities are equal. Hence

$$k_1.C_A \times C_B = k_2.C_C \times C_D,$$

that is

$$\frac{C_C \times C_D}{C_A \times C_B} = \frac{k_1}{k_2} = K_C.$$

K_C is the *equilibrium constant*, or *dissociation constant* if the reaction is a dissociation, and its value depends on the temperature and on the units chosen for mass and volume. Concentrations are usually expressed by means of square brackets. The above expression for the law of mass action may be given for any reaction if the number and nature of both the reacting and resulting molecules is known. Thus for the reaction

$$aA + bB \rightleftharpoons cC + dD,$$

where a mols of A react with b mols of B to give c mols of C and d mols of D, the law of mass action gives

$$\frac{[C]^c \times [D]^d}{[A]^a \times [B]^b} = K_c.$$

If the reaction is a gaseous one, the expression may be written

$$\frac{(p_C)^c \times (p_D)^d}{(p_A)^a \times (p_B)^b} = K_p,$$

where p_C, p_D, p_A, and p_B are the partial pressures (say, in atmospheres). The numerical value of K will, of course, be different in these units. If the total number of molecules on each side of the equilibrium equation is the same the position of the equilibrium, and hence the value of K, will be independent of the volume of the system. In other cases the value of K will depend on the unit of volume chosen. This is illustrated in the application of the mass law to electrolytic dissociation equilibria (*see* Dilution Law). The active mass of a solid is constant and hence the term expressing it may be omitted; *e.g.*, in the above equation if B and D are solids, then

$$\frac{[C]^c}{[A]^a} = K$$

The law of mass action—or the *mass law*, as it is frequently called—deals essentially with chemical equilibria, and the terms given in the expression of the law are always terms expressing concentrations at equilibrium. The law, which is of wide applicability and fundamental importance, was first enunciated by Guldberg and Waage, and is sometimes known by their name. *See* Dilution Law, Distribution Law, van't Hoff Isochore, Affinity (Chemical), Chemical Equilibrium, and Reaction Velocity.

Mass Law.—*See* Mass Action, Law of.

Mass Spectra.—*See* Positive Ray Analysis.

Maumené Number.—The number of degrees rise in temperature (C.°) observed when a given quantity of oil is treated with concentrated sulphuric acid. The oil (50 grams) and the acid are brought to the same temperature (say, 20°) and the acid (10 c.cs.) stirred into the oil, in which a thermometer is immersed (the stirring is frequently done with the thermometer). The oil may be diluted with a known quantity of another oil (*e.g.* olive or mineral oil) or with a solvent (*e.g.* CCl_4).

Maximum Work.—*See* Affinity (Chemical).

Maxwell's Distribution Law.—If in a mass of gas of n molecules a number dn have a velocity lying between v and $v + dv$, then

$$dn = \frac{4nv^2}{u^3\sqrt{\pi}} \cdot e^{-\frac{v^2}{u^2}} \cdot dv,$$

where u is the *root-mean-square velocity* and e the base of the natural logarithms. The root-mean-square velocity is given by

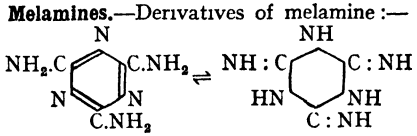
$$u^2 = \frac{v_1^2 + v_2^2 + v_3^2 + \ldots}{n};$$

i.e. it is the square root of the sum of the squares of the separate velocities of the individual molecules divided by the total number of molecules.

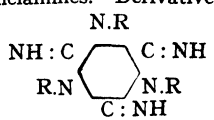
Me.—*See* Methyl (Group, Radical).

Mean Calorie.—*See* Calorie.

Melamines.—Derivatives of melamine:—



The symmetrical trialkyl melamines corresponding to the above formulæ are known as exo-trialkylmelamines. Derivatives of the type



are known as eso-trialkylmelamines.

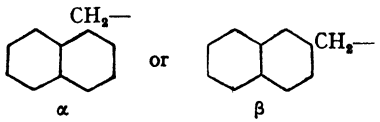
Melanins.—Black colouring matters of various composition forming the black pigments of animals, black hair, the skin of the negro, etc.

Melissyl- (Radical).—*See* Myricyl (Radical).

Melting Point.—The temperature at which the solid phase is converted to liquid phase; *i.e.*

the temperature at which solid and liquid phases are in equilibrium. In general, this temperature depends on the pressure, but melting points are ordinarily given for atmospheric pressure (760 mm.).

Menaphthyl (Radical).—The grouping



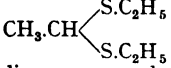
Analogous to Benzyl.

Mendeleef's Law.—(1) In the acyclic hydrocarbon series having the general formula C_nH_{2n} the number of primary carbon atoms (*i.e.* C atoms attached to one other C atom) is equal to the sum of the tertiary carbon atoms (*i.e.* C atoms having three valencies attached to carbon) plus twice the number of quaternary carbon atoms (*i.e.* C atoms having all four valencies attached to carbon). (2) *See* Periodic System.

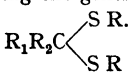
Mendius' Reaction.—The reduction of the cyano group —C ⋮ N to the primary amine group $-CH_2NH_2$ by means of sodium and alcohol; *e.g.*

$$C_2H_5C \vdots N \rightarrow C_2H_5CH_2NH_2.$$

Mercaptals.—Sulphur analogues of the acetals (*i.e. thioacetals*); *e.g.*



The corresponding compounds derived from ketones and having the general formula



are sometimes termed *mercaptols*. *See* Acetals.

Mercaptans.—Organic compounds containing the mercapto group —SH attached to carbon. They are thus the sulphur analogues of the alcohols and phenols and are often referred to as *thioalcohols* and *thiophenols* respectively; *e.g.* C_2H_5SH, ethyl mercaptan; C_6H_5SH, phenylmercaptan. *See* Geneva Nomenclature.

Mercaptides.—Metallic derivatives of the mercaptans formed by replacing the hydrogen of the SH group by a metal. They are thus the sulphur analogues of the methoxides, ethoxides, phenates, etc.; *e.g.* mercury ethylmercaptide, $Hg(S.C_2H_5)_2$.

Mercapto-.—*See* Mercaptans.

Mercaptols.—*See* Mercaptals.

Mercuration.—Mercurisation (*q.v.*).

Mercuriammonium Compounds.—*See* Ammono-Compounds.

Mercuriated Ketones.—Molecular compounds of certain ketones with mercury salts, such as mercuric chloride; *e.g.* acetophenone mercurichloride.

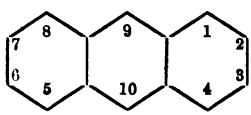
Mercurisation.—The formation of certain complex organic compounds containing mercury. *E.g.* aromatic amines of the type $C_6H_5NR_1R_2$ combine with one molecule of a mercury salt, HgX, to give the compound $XHg.C_6H_4NR_1R_2$. Similarly, phenol ethers of the type C_6H_5OR give the compound $XHg.C_6H_4OR$. The mercury is directly attached to carbon, generally in the *para* position, but *ortho* if the *para* position is occupied. X=Cl or CH_3COO.

Meriquinonoid (Meriquinoid).—*See* Quinhydrones.

Merochrome.—A name given by Hantzsch to certain chromoisomers which are regarded as mixed crystals or solid solutions of the colourless and coloured isomers.

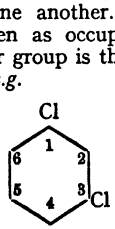
Merotropism (Merotropy).—Tautomerism. *See* Isomerism, Dynamic.

Meso-.—A prefix employed to denote the position of certain carbon atoms in polycyclic compounds. More commonly applied to the positions 9 and 10 in the anthracene (and anthraquinone) and acridine nucleus:—

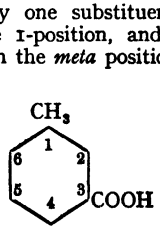


The abbreviation *ms-* is frequently used; *e.g. ms*-nitro-anthracene is 9- (or 10) nitro-anthracene.

Meta-.—(1) In disubstituted benzenes substituents in the 1, 3-positions are said to be *meta* to one another. Usually one substituent is chosen as occupying the 1-position, and the other group is therefore in the *meta* position to it; *e.g.*



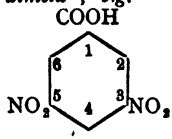
Meta-dichlorbenzene



Meta-toluic acid.

There are two meta positions with respect to any substituent, viz. the positions 3 and 5. I

both these positions are occupied the compound has the prefix *dimeta-*; *e.g.*



Dimeta-nitrobenzoic acid

The prefix is usually abbreviated to *m-*.

(2) A prefix given to certain inorganic acids of lower basicity than the ortho acids, from which they may be regarded as derived by loss of one molecule of water; *i.e.* two OH groups are replaced by one O; *e.g.*

$Si(OH)_4$	→	$SiO(OH)_2$
Orthosilicic acid		Metasilicic acid
$B(OH)_3$	→	BO OH
Orthoboric acid		Metaboric acid

See Ortho, and Para.

Metabolic Equilibrium.—When the intake and output of the food constituents of an animal, with reference to any significant element, are equal, the animal is said to be in nitrogen equilibrium, phosphorus equilibrium, etc.

Metabolism.—A general name for the chemical changes undergone by the constituents of the food taken into the animal body. These changes may consist either (1) in a breaking down of the food constituents into simpler substances (*catabolism*) or (2) in the building up of more complex substances from the simple (*anabolism*).

Metabolites.—In general, products of metabolism in the animal body. The name is used more especially in connection with those unknown products of cell metabolism which influence the rate of blood flow.

Metachemistry.—That branch of chemistry which deals with the changes of sub-atomic or infra-atomic structures and properties, such as radioactivity.

Metakliny.—A name suggested for certain intramolecular rearrangements, such as the benzilic acid and pinacone-pinacoline rearrangements, in which a group is transferred from one side of the molecule to the other.

Metal-ammino Compounds.—*See* Ammines.

Metal-ketyls.—Compounds formed by the combination of certain ketones and metals; *e.g.* one atom of potassium combines with one molecule of phenyl-biphenyl ketone,

$$C_6H_5COC_6H_4.C_6H_5.$$

Similarly, benzophenone, $C_6H_5COC_6H_5$, adds one or two atoms of sodium. The resulting compounds show similarities to the free radicals (*q.v.*), but their constitution is not yet definitely elucidated.

Metallicity.—The nature and properties of metals. The metallic state.

Metalloids.—A term sometimes applied to those elements which show some of the characteristic properties of both metals and non-metals; *e.g.* arsenic, boron, silicon.

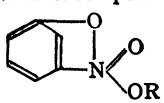
Metallo-organic Compounds.—*See* Organometallic Compounds.

Metameric.—Compounds having the same molecular weight and percentage composition (*i.e.* having the same molecular formula) but possessing different properties (*i.e.* belonging to distinct chemical classes) are said to be metameric. This class of isomerism is termed *metamerism*; *e.g.* acetone and allyl alcohol, C_3H_6O. The term is now seldom used. *See* Isomerism

Metamerism.—*See* Metameric.

Metaproteins.—Substances formed at an early stage in the hydrolysis of proteins by acids or alkalis. They possess most of the properties of the proteins but do not coagulate on heating.

Meta-quinones.—A name designating certain compounds of the metanitrophenols and their ethers, to account for the phenomenon of chromoisomerism. The following structure has been proposed for these compounds:—



They have not, therefore, a quinonoid structure, but correspond to the peroxides. *See* Chromoisomerism.

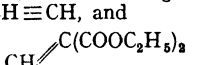
Metastable Equilibrium.—Many systems do not pass spontaneously into a state or phase of stable equilibrium under the conditions necessary for the latter. They are said to be in metastable equilibrium. *E g.* many liquids can be cooled below their freezing points without solidification taking place, and the allotropic modifications of certain substances may persist above or below their transition temperatures. If some of the substance in the stable phase be added, transformation of the whole of the unstable phase to the stable takes place. Such substances, phases, or systems are said to be in the *metastable state*, and the temperature region throughout which they exist is termed the

metastable region. The phenomenon is also referred to as *suspended transformation.*

Metastable Region.—*See* Metastable Equilibrium.

Metastable State.—*See* Metastable Equilibrium.

Methenyl- (Group, Radical).—The tervalent group =CH—, or CH≡; *e.g.* acetylene (dimethenyl), CH≡CH, and



Methenyl-dimalonic ester.

Also termed the *methine* group. *See* Azomethines.

Methides.—The metal-methyls; *e.g.* zinc methyl, $Zn(CH_3)_2$.

Methionyl- (Radical).—The bivalent group $—SO_2.CH_2.SO_2—$. From methionic acid, $CH_2(SO_3H)_2$.

Methoxides.—Compounds obtained by replacing the alcoholic hydrogen atom in methyl alcohol by a metal or positive group; *e.g.* sodium methoxide, $NaOCH_3$. Also termed *methylates*, but methoxides is to be preferred. *See* Alcoholates.

Methoxy (Methoxyl) (Group, Radical).—The univalent group —O.CH_3. Often abbreviated to OMe in formulæ.

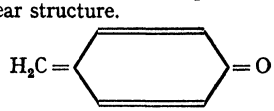
Methylates.—*See* Methoxides, and Alcoholates.

Methylation.—The introduction of one or more methyl groups into the molecule of an organic compound. The term is more usually reserved for those cases in which the group is not directly attached to carbon, but to oxygen, nitrogen, etc., as in the methylation of aniline, $C_6H_5NH_2$, to give dimethylaniline, $C_6H_5N(CH_3)_2$, phenol, C_6H_5OH, to give anisole, $C_6H_5OCH_3$, and so on. Methylations are generally carried out with dimethyl sulphate, methyl chloride, or methyl alcohol and hydrochloric acid. *See* Exhaustive Methylation.

Methyl- (Group, Radical).—The univalent group —CH_3. The abbreviation Me is often used in formulæ.

Methylene (Group, Radical).—The bivalent group —CH_2—, or CH_2=.

Methylene Quinones.—Compounds containing the nuclear structure.



Mho.—*See* Reciprocal Ohm.

Miazines.—Meta-diazines *See* Azines.

Micellæ (Colloidal, Ionic).—The high conductivity of the colloidal electrolytes (*q.v.*) is ascribed to the presence of highly charged colloidal aggregates, which behave in much the same manner as the ordinary electrolytic ions. These colloidal aggregates have been called colloidal, or ionic, micellæ. The conductivity of the colloidal sodium and potassium palmitates and stearates (*i.e.* the soaps) is explained as due to these micellæ, which are produced from the palmitate or stearate ions.

Michael's Reaction.—The sodium compounds of acetoacetic, malonic, cyanacetic, etc., esters form additive compounds with unsaturated compounds of the type

R.CH=CH.X or R.C≡C.X,

in which R is a positive or negative group and X a strongly negative group. The sodium attaches itself to the most negative group (X). Fumaric and maleic esters, benzalacetone, etc., react in this way Many important syntheses can be carried out by means of this reaction; *e.g.*

$C_6H_5CH=CH.COOEt + NaCH(COOEt)_2 \longrightarrow$

Cinnamic ester — Sodium malonic ester

$C_6H_5CH.CHNa.COOEt \xrightarrow{H_2O} C_6H_5CH.CH_2COOH$

$CH(COOEt)_2$ — CH_2COOH

(Et=ethyl) — β-phenylglutaric acid

Microanalysis.—That branch of chemical analysis which deals with analytical methods employing very small quantities of substance. These methods generally involve the use of specially sensitive and accurate apparatus, often constructed on a very small scale. These frequently have the prefix micro-; *e.g.* the Steele-Grant microbalance, which can be used to measure the loss in weight of silver chloride when exposed to light. Other forms of well-known apparatus on a small scale and suitably modified are the micro-calorimeter, micro-Kipp apparatus, micro-pycnometer, and so on. The methods sometimes involve the use of a lens or microscope. The recent developments of micro-analysis are largely due to Pregl.

Micrography.—The photography of the physical structure of substances under high magnification.

Microns.—Particles whose size (diameters) ranges from 0·2μ to 10μ. These show some of the properties of the colloidal state, such as cataphoresis and Brownian movement. The

limit 0·2μ corresponds to the limit of microscopic visibility.

Migration (Intramolecular).—*See* Intramolecular Change, and Molecular Transposition.

Migration (Ionic).—*See* Ionic Mobility, and Transport Numbers.

Migration Velocity.—*See* Ionic Mobility, and Transport Numbers.

Millon's Reagent.—Mercury is dissolved in its own weight of strong nitric acid. The solution is diluted with twice its volume of water, allowed to settle, and the clear liquid decanted off. This reagent is used for detecting protein, with which it gives a white precipitate turning brick-red on boiling.

Mineralogical Chemistry.—That branch of chemistry which deals with mineral substances, *i.e.* naturally occurring substances such as ores, clays, shale, sands, salts, etc.

Mitscherlich, Law of.—Compounds having the same number of atoms combined in the same way crystallise in the same form; *i.e.* the crystal form depends only on the number and arrangement of the atoms and is independent of their chemical nature (Mitscherlich's Law of Isomorphism). There are many exceptions to this law, and it has been found that in those cases where the law applies the crystals, although belonging to the same crystal form, are not absolutely identical.

Mixed Amines.—*See* Amines.

Mixed Anhydrides.—*See* Anhydrides.

Mixed Crystals.—Crystals of isomorphous (and isodimorphous) substances may be obtained which contain both substances. These mixed crystals may be obtained by subliming a mixture of the two substances, or by solidification of a fused (liquid) mass of the two, or by crystallisation from a solution containing both. In most cases the crystals can contain both constituents in all proportions; *e.g.* naphthalene and β-naphthol, $HgBr_2$ and HgI_2. In other cases the proportions are limited; *e.g.* $AgNO_3$ and $NaNO_3$. *See* Solid Solutions.

Mixed Ethers.—*See* Ethers.

Mobile (or Movable) Equilibrium, van't Hoff's Law of.—If a system in equilibrium is subjected to an increase of temperature that change will ensue in the system which is accompanied by an absorption of heat, and conversely. *E.g.* if ice is heated it will melt (*i.e.* take up latent heat of fusion); if water be heated it will evaporate (*i.e.* absorb latent heat of vaporisation). If heat be added to a chemical system in equilibrium an endothermic reaction will result. This is a special case (for temperature) of Le Chatelier's Principle (*q.v.*). *See also* van't Hoff Isochore.

Mobility, Ionic.—*See* Ionic Mobility, and Transport Numbers.

Mol.—Gram-molecule (*q.v.*).

Molar.—Gram-molecular; *e.g.* a molar solution contains the molecular weight of a substance in grams per litre. The gram-molecular weight is also termed the *molar weight* or *molweight* The term is also employed as a distinction from *molecular*, the latter applying to actual molecules and *molar* to substances in bulk. The colloidal state is intermediate between the molar and molecular. *See* Gram-molecule, and also under Molecular —.

Molar Conductivity.—*See* Conductivity, Electrical.

Molecular Association.—*See* Association, Molecular.

Molecular Asymmetry.—*See* Asymmetry, Molecular.

Molecular Attraction.—The individual molecules in a mass of substance exert an attractive force on one another. In gases this force only becomes effective when the molecules are very near to each other, the range of molecular attraction being about 10^{-7} cms. This attractive force is one of the disturbing factors in the application of the gas law. It has been allowed for in the several equations of state (*q.v.*). *See* Joule-Thomson Effect.

Molecular Compounds.—There are many cases where single compounds unite in definite molecular proportions to give a new compound differing to a greater or less extent in physical properties. These so-called *molecular compounds* are generally derived from simple compounds in which the ordinary valencies of the atoms are regarded as saturated. The combination may be attributed to residual valencies acting between one atom in one of the compounds and one atom in the other. Several types of addition compounds of this kind may be distinguished. Thus there are compounds such as KF.HF; $LiCl.CuCl_2.2H_2O$; $NaCl.ZnCl_2$: the alums, etc. These are known as *double salts*. In solution they react as mixtures of the two component compounds, furnishing the same ions. Salts having water, alcohol, etc., of crystallisation may be also regarded as molecular compounds. Another type is represented by the *complex salts*, such as, *e.g.*, the ferrocyanides, which are obtained by combination of ferrous cyanide with

another cyanide such as potassium cyanide,

$$Fe(CN)_2 + 4KCN = K_4Fe(CN)_6,$$

and the argenticyanides, which are formed in an analogous manner from silver cyanide and another cyanide; *e.g.*,

$$AgCN + KCN = K.Ag(CN)_2.$$

In these cases, however, the new compound is chemically distinct from its congeners. Thus $K_4Fe(CN)_6$ gives no reactions for Fe or CN ions in solution, but forms a new ion $Fe(CN)_6''''$. Ions produced in this way from complex compounds are termed *complex ions*. Another type is represented by the ammines (*q.v.*), but here again the resulting *complex compounds* are quite distinct from the simple metallic salts and ammonia from which they are produced. Organic compounds also form molecular compounds. *See, e.g.*, Carbonium Compounds, Addition Compounds, *and under* Formulæ (Chemical), Co-ordination. Addition compounds formed owing to unsaturation of the ordinary or principal valencies in one of the compounds are not classed as molecular, and although it is difficult to draw a line of distinction in some cases it is perhaps better to apply the term *molecular* only to those compounds in which the chemical individuality of the component molecules is more or less retained.

Molecular Conductivity.—*See* Conductivity, Electrical.

Molecular Co-volume.—*See* Equations of State.

Molecular-disperse.—A disperse system in which the disperse phase is in the molecular condition; *i.e.* a true solution.

Molecular Dispersion.—*See* Dispersion (Light).

Molecular Elevation (Boiling Point).—*See* Raoult's Law.

Molecular Exaltation.—*See* Optical Exaltation.

Molecular Formulæ.—*See* Formulæ (Chemical).

Molecular Heat.—The specific heat of a compound multiplied by its molecular weight. It is therefore the amount of heat required to raise one gram-molecule one degree C.°. The molecular heat is approximately the sum of the atomic heats. *See* Atomic Heat, and Joule's Law.

Molecular Lowering (Depression) (Freezing Point).—*See* Raoult's Law

Molecular Magnetic Rotation.—*See* Magnetic Rotation.

Molecular Magnetisation.—*See* Specific Magnetisation

Molecular Refraction (Refractivity).—The specific refraction multiplied by the molecular weight Thus

$$M = \frac{(n-1)m}{d}$$ Gladstone and Dales' Formula

$$\mathfrak{M} = \frac{n^2-1}{n^2+2} \cdot \frac{m}{d}$$ Lorenz and Lorentz' Formula

where m is the molecular weight. Since refractive indices are usually determined for the D (sodium) line the molecular refractions are designated by M_D or $\mathfrak{M}_D$. The molecular refraction is the sum of the atomic refractions, making due allowance for the mode of combination of the atoms, the presence of double or triple bonds, etc. Double and triple bonds are designated by the symbols $\overline{|}n$ and $\overline{\overline{|}}n$ respectively, n being the number of such bonds present. For the ethenoid linking the correction—or *increment* as it is called—is 2, and for the acetylenic triple bond 2·2. These numbers have to be added for each of these bonds present, in calculating the molecular refraction from the sum of the atomic refractions. Molecular refraction is thus an additive property. *See* Atomic Refraction.

Molecular Rotation.—*See* Optical Activity.

Molecular Solution Volume.—According to Traube the volume occupied by a gram-molecule of a substance of molecular weight m when dissolved in w grams of solvent is given by

$$V = \frac{m+w}{D} - \frac{w}{d},$$

where D is the density of the solution and d that of the pure solvent. This only applies where no association takes place. It also assumes that the change in volume is due entirely to the dissolving of the substance.

Molecular Surface Energy.—Molecular surface energy is the quantity

$$\gamma(Mv)^{\frac{2}{3}},$$

where γ is the surface tension, M the molecular weight and v the specific volume ($1/d$, where d is the density). Its value diminishes with temperature. Ramsay and Shields have shown that the temperature coefficient is $-2{\cdot}121$ for all liquids, *i.e.*,

$$\frac{\gamma_2(Mv_2)^{\frac{2}{3}} - \gamma_1(Mv_1)^{\frac{2}{3}}}{t_2 - t_1} = -2{\cdot}121,$$

where γ_1 and γ_2 are the surface tensions at the temperatures t_1 and t_2. This is only true if the molecular weight remains constant The deviation, and hence the degree of molecular association, can be measured by means of this rule.

Molecular Transposition (Rearrangement, Migration).—An intramolecular change involving the migration of an atom or group from one position to another within the molecule. Such rearrangements are common in organic chemistry and are one of the causes of isomerism; *e.g.* phenylchloramine, C_6H_5NHCl, to *p*-chloraniline, $Cl.C_6H_4NH_2$; phenylhydroxylamine, C_6H_5NHOH, to *p*-aminophenol, $HO.C_6H_4NH_2$. Similar changes may result in a rearrangement of the bonds; *e.g.*,

$CH_3(CH_2)_4CH{\equiv}CH$ $CH_3(CH_2)_3C{\equiv}C.CH_3$

1-Heptine 2-Heptine

For further examples *see* Pinacone-Pinacoline and Benzilic Acid Rearrangements, and Beckmann Reaction. *See also* Isomerism, Keto-enol; and Conjugated Double Bonds.

Molecular Volume.—The volume in c.cs. occupied by the gram-molecular weight of a compound. It is therefore the specific volume × molecular weight, or the molecular weight ÷ density. The term *molvolume* is sometimes employed.

Molecular Weight.—The sum of the atomic weights of all the atoms in the molecule of an element or compound. Thus the molecular weight of oxygen, which is diatomic, is $2 \times 16 = 32$; that of phosphorus, which is tetratomic, is $4 \times 31 = 124$. The molecular weight of silver nitrate is $(Ag = 108) + (N = 14) + (3O = 3 \times 16 = 48) = 170$; that of the compound $C_{14}H_8O_2$ is 208, and so on.

Molecules.—A molecule results from the combination of atoms. It is therefore a system of atoms bound together by chemical forces. If two or more atoms of different kinds combine the molecule is the molecule of a compound. If the atoms are all the same the molecule is the molecule of an element. The forces which bind the atoms together are termed valencies or bonds. With the exception of the rare gases (*q.v.*) the atoms of the elements combine to give molecules. In the case of the rare gases therefore it may be said that the molecule and atom are identical. These elements are therefore termed *monatomic*. Those elements whose molecules contain two atoms (*e.g.* N, O, Cl. etc.) are *diatomic*, those with three (*e.g.* ozone) are *triatomic*, and those with four *tetratomic* (*e.g.* P). Molecules with several atoms are classed as *polyatomic*. Molecules are thus the ultimate indivisible particles of compounds. They are the smallest particles of a compound which can have a free and independent existence. *See* Atoms, and Ions.

Molisch's Reaction.—A test for carbohydrates. One drop of a solution of α-naphthol is added to 5 c.cs. of the carbohydrate solution and then 5 c.cs. of concentrated sulphuric acid. A purple coloration is produced. This is due to hydroxymethylfurfural condensing with the α-naphthol.

Moloxide.—*See* Autoxidation.

Molvolume.—Molecular Volume (*q.v.*).

Molweight.—Gram-molecular weight. *See* Gram-molecule.

Monads.—Univalent elements. The term is seldom used. *See* Valency.

Monatomic.—*See* Atomicity, and Molecules.

Monazines.—*See* Azines.

Monazoles.—*See* Azoles.

Monochromic Salts.—Salts which occur in one colour only; *i.e.* salts whose colour depends on the colour of the ions of the base and acid from which it is formed. *Cf.* Chromoisomerism.

Monobasic.—*See* Basicity.

Monoclinic (Crystals).—Crystals having one plane and one dyad axis of symmetry. Also termed *clinorhombic*, *monosymmetric*, and *oblique*. Borax, cane sugar, etc., crystallise in this system. *See* Symmetry, Crystal.

Monocyclic.—*See* Cyclic Compounds.

Monoketones.—*See* Ketones.

Monomolecular Layer.—There are many cases known of one substance forming a film on the surface of another, which films have a thickness corresponding to the diameter of the molecules of the substance. The formation of these *monomolecular layers* is probably due to the attraction of the unsaturated affinities of the molecules on the surface for those of the substance forming the layer. The theory of the monomolecular layer has been advanced in explanation of the phenomena of sorption (*q.v.*).

Monomolecular Reaction.—*See* Reaction Velocity.

Monosaccharoses (Monosaccharides).—*See* Sugars.

Monoses.—*See* Sugars.

Monosymmetric.—*See* Monoclinic.

Monotropy (Monotropic).—*See* Allotropy.

Monovalent.—*See* Valency.

Moore's Test.—A test for sugar. When dextrose is heated with strong potash a yellow or brown colour is produced owing to the formation of complex acids.

Mordants.—Substances used in the dyeing of textiles in order to fix the dyestuff to the fibre and render it fast. They also produce different

shades. Basic mordants, such as the hydroxides of aluminium, chromium, iron, etc., are employed for acid dyestuffs; and acid mordants, such as tannin, for the basic dyestuffs.

Mörner's Test.—A test for tyrosine. A green coloration is produced on boiling a solution of tyrosine with a solution of formalin in dilute sulphuric acid.

Morphotropy.—The study of crystallographic changes due to differences in the internal structure of the molecule; *i.e.* differences in the atomic arrangement such as the replacement of one atom by another (and different) one.

ms.—*See* Meso.

Mucilages.—Substances found widely distributed in plants, which form slimy liquids with water. They are essentially complex polysaccharoses containing hexose and pentose units. *See* Gums, and Hemicelluloses.

Mucins.—*See* Gluco-proteins.

Mucoids.—*See* Gluco-proteins.

Multiple Proportions, Law of.—If an element combines with another element in two or more different proportions by weight (giving two or more different compounds) these proportions bear a simple ratio to one another. *E.g.* nitrogen and oxygen combine to give five different oxides, N_2O, NO, N_2O_3, N_2O_4 (or NO_2), and N_2O_5. The amounts of oxygen combined with one part by weight of nitrogen in these five compounds are 0·571, 1·142, 1·713, 2·284, and 2·885 respectively. These are in the ratio 1 : 2 : 3 : 4 : 5. The law was first enunciated by Dalton and is sometimes known by his name.

Multirotation.—Mutarotation (*q.v.*).

Multivalent.—Polyvalent. *See* Valency.

Multivariant (System).—*See* Phase Rule.

Murexide Test.—A test for uric acid. If dilute nitric acid be added to uric acid and the mixture evaporated to dryness a yellowish-red residue is left. On adding a little ammonia the residue turns violet.

Mutarotation.—The solutions of many optically active compounds show a gradual change in rotatory power on standing. This is characteristic of many sugars; *e.g.* *d*-glucose has $[\alpha]_D = +110°$. On standing this gradually falls until the constant value +52·5° is reached. Similarly fructose changes from −140° to −93°; mannose from −14° to +14°, and lactose from +86° to +55·3°. Other classes of compounds also show this behaviour; *e.g.* nitro-camphor. The change is due to isomerisation of the compound into an optical isomer having a lower or opposite rotatory power until an equilibrium is reached. Also termed Multirotation and Birotation, but these terms are now seldom used.

Myricyl- (Radical).—The primary group $C_{30}H_{61}$—. Also termed melissyl.

Myristyl- (Radical).—The normal group $CH_3(CH_2)_{12}CO$—. The radical of myristic acid.

N

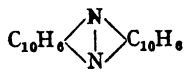
N, *n.*—*See* Table of Symbols, p. 157.

N-.—In compounds in which alkyl, aryl, etc., groups may be attached to oxygen or nitrogen, the attachment in the latter case is indicated and distinguished by N-alkyl, N-aryl, etc.

Naphth- (Naphtho-).—A prefix indicating the presence of the naphthalene nucleus, as, *e.g.*, in naphthazines (*q v.*), dinaphthacridines (*q v.*), naphthiminazoles, naphthoquinones, etc. Analogous to benz- and benzo- (*q v.*). Certain compounds have names beginning with naphth- which, however, do not contain the naphthalene nucleus, such as the naphthenes.

Naphthalides. — Acylated naphthylamines, $C_{10}H_7NHX$, where X = acetyl, benzoyl, etc. Analogous to the anilides (*q.v.*).

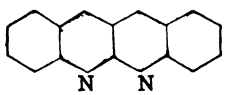
Naphthazines.—The αα-, αβ-, or ββ-naphthazines



and their derivatives. *See* Azines.

Naphthenes.—*See* Cycloparaffins.

Naphthinolines.—Derivatives of the compound (naphthinoline) :—



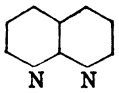
Naphthols.—The phenols of the naphthalene series.

Naphthoyl- (Radical).—The group $C_{10}H_7.CO$—. The acid radical of the α- or β-naphthoic acids.

Naphthylene- (Radical).—The bivalent group $-C_{10}H_6-$, from naphthalene. Analogous to phenylene (*q.v.*); *e.g.* the 1,2-, 2,3-, 1,8-, etc., naphthylenediamines (diaminonaphthalenes).

Naphthyl- (Radical).—The univalent group $C_{10}H_7-$, from naphthlene. Analogous to phenyl (*q.v.*).

Naphthyridines.—Derivatives of naphthyridine;



Narcosis.—The effect produced by narcotics (*q.v.*).

Narcotics.—Substances which produce temporary abolition of vital activities in living cells, and in consequence produce varying degrees of lethargy and unconsciousness with paralysis. The effects are essentially the same as those of anæsthetics, but the name is usually reserved for those non-volatile substances which produce more lasting effects than the volatile anæsthetics.

Nascent State.—Some elements at the moment of their liberation from a compound exhibit enhanced chemical activity. Thus oxygen, when liberated from water by the action of chlorine, is a powerful bleaching agent; it readily oxidises certain dyestuffs. Ordinary gaseous oxygen does not behave in this way. Again, ordinary hydrogen gas does not effect reductions readily by itself, but if a reducible substance is present in a reaction which liberates hydrogen, such as, *e.g.*, Zn + H_2SO_4, Sn + HCl, Na + alcohol, reduction takes place much more readily. Elements at the moment of their liberation are said to be in the nascent state (*in statu nascendi*). The increased activity of nascent oxygen, hydrogen, etc., has been ascribed to the gas being in the atomic condition, the heat of formation of the molecules being thus available for starting or accelerating another reaction (oxidation, reduction, etc.). The atoms have a tendency to lose or gain electrons, and they may even be in the ionic condition, in which state they would be more chemically reactive. It has been found, however, that certain gases are more reactive when in the form of very minute bubbles, which would seem to indicate that the reactivity depends on a state of very fine mechanical division. The problem is not yet satisfactorily solved.

Negative Catalysis.—The normal velocity of many reactions is more or less diminished by the presence of small quantities of certain substances. This retardation of the progress of a chemical reaction is termed *negative catalysis*, and the substances which produce it *negative catalysts*; *e.g.* the oxidation of sodium sulphite by atmospheric oxygen is suppressed by small quantities of mannose or benzaldehyde. The formation of the Grignard reagents (*q.v.*) in ether is retarded by traces of such compounds as acetone and esters. Water is a negative catalyst in many reactions, such as the decomposition of oxalic acid by concentrated sulphuric acid. *See* Catalysis.

Negative Catalysts.—*See* Negative Catalysis.

Negative (Groups, Radicals).—*See* Electropositive.

Negative-positive Rule.—In addition reactions at a double bond the electropositive atom or group will attach itself to the more electronegative atom of the unsaturated grouping and the electronegative atom or group to the more electropositive atom in the unsaturated grouping. A term proposed by Michael. *See* Michael's Reaction.

Nephelometer.—An instrument for studying the character of suspensions by means of diffuse transmitted or reflected light, such as the Tyndall beam. There are several types of this instrument which have also been termed *tyndallmeters* and *turbidimeters*.

Nephelometry.—The study of the nature, concentration, size of particles, etc., of a suspension by means of the nephelometer (*q.v.*).

Nernst's Distribution (Partition) Law.—*See* Distribution Law.

Nernst's Heat Theorem.—A thermodynamic theorem giving the quantitative relation between the free energy change, A, and the total energy change, U, of a reaction. The theorem takes the form

$$A = U_0 - \beta T^2 - \frac{\gamma}{2} T^3 - \frac{\delta}{4} T^4 \ldots,$$

where U is the value of U at the absolute zero, β, γ, and δ are constants and T the absolute temperature. The relation between U and U_0 is given by

$$U = U_0 + \beta T^2 + \gamma T^3 + \delta T^4 \ldots.$$

The above expressions are for condensed systems only. In many cases the values for the constants β, γ, and δ are very small. *See* Free Energy.

Nernst-Thomson Rule.—*See* Dielectric Constant.

Nesslerisation.—A name suggested for the testing of liquids (*e.g.* urine) by the Nessler Reagent (*q.v.*).

Nessler's Solution (Reagent).—A reagent for the detection and estimation of ammonia. It consists of mercuric iodide in potassium iodide

solution made alkaline with potassium hydroxide.

Neutralisation.—The addition of the equivalent quantity of a base to an acid or *vice versa* so that the resulting compound (salt) no longer shows the properties of an acid or base; *i.e.* it no longer gives acid or alkaline reactions. *See* Indicators, and Titration.

Neutralisation Value.—The number of milligrams of potassium hydroxide required to neutralise one gram of a fatty acid. A value employed in the evaluation of fats and oils.

Ninhydrin Reaction.—A test for proteins and amino-acids in which a blue colour is developed by boiling the protein solution with a very dilute solution of triketohydrindene hydrate.

Nitramines (Nitro-amines).—Primary or secondary amines in which a nitro group is attached to the nitrogen atom; *e.g.* phenylnitramine, $C_6H_5NH.NO_2$.

Nitration.—The introduction of one or more nitro groups into the molecule of an organic compound. Ordinarily the nitro group replaces hydrogen and is attached to carbon. Nitration is generally carried out with nitric acid or a mixture of nitric and concentrated sulphuric acids.

Nitrazones.—Nitro-hydrazones; *e.g.*
$CH_3C(NO_2):N.NHC_6H_5$, or
$CH_3C(NO.OH).N:NC_6H_5$.

Nitrenes.—Compounds having the general formula

$$(R)_2C{=}N{=}C(R)_2,$$
$$\quad\quad\quad

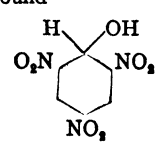
volume of nitrogen evolved in the estimation of that element in organic compounds. In its simple form, such as that of Schiff, it consists of a graduated gas burette to which is attached a levelling reservoir. The gas is collected over caustic soda. In the Lunge nitrometer, which is of somewhat different type, there are three parts, viz. two burettes and a levelling reservoir. One of the burettes contains a volume of air which would measure exactly 100 c.c. at N.T.P. In the other burette the substance undergoing analysis (chiefly nitrates) is decomposed with concentrated sulphuric acid in presence of mercury (which fills all the three vessels). Nitric oxide is quantitatively evolved and the volume is read off by making the mercury meniscus in the decomposition tube level with that in the tube containing the standard volume. The volume of NO at N.T.P. is thus obtained directly.

Nitrones.—Compounds having the general formula

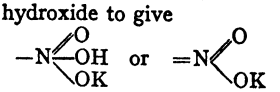
$$(R)_2C{=}N{-}R.$$
$$\|$$
$$O$$

The group C=N(:O)— is termed the nitrone group. Compounds containing two such groups are termed *dinitrones*, *e.g.* Ph.N:CPh.CPh.N.Ph (ketodinitrone), and PhN:CH.CH:NPh (aldodinitrone). (Ph = phenyl).

Nitronic Acids.—Compounds containing the isonitro group (*q.v.*). The symmetrical trinitro benzenes and toluenes show acid properties and combine with KOH, NaOH, etc., to give coloured salts. They are probably derived from the compound



One of the nitro groups $-N\langle^{O}_{O}$ combines with the alkali hydroxide to give



The latter is the isonitro group. Hantzsch gave the name nitronic acids to these compounds.

Nitrosamines.—Compounds having the general formula

$$R'.N.R''$$
$$|$$
$$NO$$

where R' and R'' are alkyl or aryl radicals. They are formed by the action of nitrous acid on secondary amines; *e.g.* phenylmethylnitrosamine, $C_6H_5N(NO)CH_3$. *See* Liebermann's Nitroso Reaction.

Nitrosates.—Compounds containing the groupings

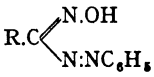
$$-C.NO \quad | \quad -C.O.NO_2 \qquad \text{or} \qquad -C.O.NO \quad | \quad -C.NO_2 \qquad \text{or} \qquad -C.O.NO_2 \quad | \quad -C.NO_2$$

(Gabriel) (Wallach)

The term nitrosates has been variously applied to all three.

Nitrosation.—The introduction of the nitroso group into the molecule of an organic compound, as in the case of nitrosophenol.

Nitrosazones.—Compounds having the general formula



i.e. phenylazoaldoximes.

Nitrosites.—Compounds containing the grouping

$$-C(NO)-C(O.NO)-$$

See Pseudonitrosites.

Nitroso-azo- (Compounds).—Compounds of the type

$$R.N{=}N.R$$
$$\|$$
$$O$$

This is the formula given by Angeli to the azoxy- compounds (*q.v.*).

Nitrosochlorides.—Compounds resulting from the addition of nitrosyl chloride, NOCl, to a double bond; *e.g.* pinene nitrosochloride and tetramethylethylene nitrosochloride, $(CH_3)_2C(NO).CCl.(CH_3)_2$.

Nitroso- compounds.—Compounds containing the nitroso- (nitrosyl) group, —NO; *e.g.* nitrosophenol, $HO.C_6H_4NO$. *See* Nitrosochlorides, Nitrosamines, Nitrols, and Nitrosites.

Nitroso- (Group, Radical).—*See* Nitrosyl- (Group, Radical).

Nitrosolic Acids.—Compounds having the general formula

Nitrosyl- (Group, Radical).—The univalent group —N=O. In organic compounds it is more frequently referred to as the nitroso group, but in inorganic compounds nitrosyl is more often employed; *e.g.* nitrosyl chloride, NOCl; nitrosylsulphuric acid, $HO.SO_2O.NO$, etc. *See* Nitroso- compounds.

Nitroxyls.—Certain metals (*e.g.* copper, nickel, iron and cobalt) unite with nitrogen peroxide giving compounds termed *nitroxyls* or *nitrometals*; *e.g.* copper nitroxyl, Cu_2NO_2, which decomposes on heating, re-generating the metal and NO_2. *Cf.* Carbonyls.

Noble Metals.—The metals silver, gold, and platinum.

Nonitols.—Nonohydric alcohols formed from the nonoses by reduction.

Nonoses.—Aldose sugars containing nine carbon atoms. *See* Sugars.

Non-polar.—*See* Polarity (Atoms).

Nonvariant.—Invariant. *See* Phase Rule.

Nonyl- (Radical).—The normal acyclic hydrocarbon group $CH_3(CH_2)_7CH_2-$, from nonane.

Nor-.—A prefix attached to the name of a compound to denote that it is derived from that compound by removal of CH_2. It is thus the opposite of homo- (*q v*).

Normal Chains.—*See* Normal Hydrocarbons.

Normal (Crystal System).—*See* Symmetry (Crystal).

Normal Dispersion.—*See* Rotatory Dispersion.

Normal Esters.—Esters of polybasic acids in which all the replaceable hydrogen is substituted by alcohol radicals; *e.g.* normal ethyl oxalate, $C_2H_5OOC.COOC_2H_5$. Esters in which an acid hydrogen atom has not been replaced are termed *acid esters*; *e.g.* acid ethyl oxalate, $HOOC.COOC_2H_5$. *See* Acid Salts.

Normal Hydrocarbons.—Hydrocarbons (and their derivatives) in which the carbon atoms are linked together in a single chain (termed a *normal chain*); *i.e.* there are no branched chains (*q.v.*). *See* Geneva Nomenclature.

Normality.—*See* Normal Solutions.

Normality Factor.—*See* Normal Solutions.

Normal Molecules.—Single molecules; *i.e.* molecules which are unassociated and which have therefore the normal molecular weight. *See* Association, Molecular.

Normal Potential.—*See* Electrode Potential.

Normal Salts.—Salts of polybasic acids in which all the replaceable hydrogen has been substituted by metal; *e.g.* normal potassium sulphate, K_2SO_4; normal sodium phosphate, Na_3PO_4. *See* Acid Salts.

Normal Solutions.—A normal solution is one containing one gram of hydrogen or eight grams of oxygen or their equivalent per litre. These solutions are employed in volumetric analysis. Other convenient strengths are half-normal, decinormal, and centinormal. The letter N is used to denote normality, half-normal being 0·5N, decinormal 0·1N, and so on. Thus N.HCl contains 36·5 grams of the acid per litre; N.NaOH contains 40 grams of sodium hydroxide per litre, 40 grams of NaOH being equivalent to 36·5 grams of HCl or the gram-molecule of any monobasic acid. A dibasic acid, such as sulphuric acid, will have two grams of hydrogen for each gram-molecule, and therefore a normal solution of such an acid will contain a half gram-molecule per litre. A normal solution of iodine will contain one gram-molecule (127 grams) per litre, since 127 grams of iodine are equivalent to one gram of hydrogen. Again, potassium permanganate ($2KMnO_4$) has five atoms of oxygen available for oxidation purposes; *i.e.* 316 grams of the permanganate will give $5 \times 16 = 80$ grams of oxygen. Since only eight grams are required for the normal solution this solution will contain $316 \div 10 = 31{\cdot}6$ grams per litre. A normal solution can thus be defined as one containing one gram equivalent of the substance per litre. Equal volumes of normal solutions are thus chemically equivalent —1 c.c. of a normal solution of an acid will exactly neutralise 1 c.c. of a normal solution of an alkali. The strength of a solution expressed as a multiple or fraction of the normal is termed the *normality*, and the multiple or fraction the *normality factor*. Sometimes normality is expressed in grams *per* 1,000 *grams of solution*. This is termed *weight normality*.

Normal Valencies.—*See* Contra-valency, and Valency.

N.T.P.—Normal Temperature and Pressure, *i.e.* 0° C. and 760 mm. Gaseous volumes are frequently referred to these as standard conditions of measurement.

Nuclear.—A term applied to cyclic compounds; *e g. nuclear-synthetic* refers to methods in which ring compounds are directly synthesised from acyclic compounds. Atoms or groups attached to carbon atoms in a ring are said to

be nuclear to distinguish them from others in a side chain.

Nuclear Charge.—The nucleus of an atom consists of both positive and negative charges, and the excess of positive charges over those of the electrons in the nucleus is termed the nuclear charge. It balances or neutralises the negative charges on the electrons in the outer rings or shells. *See* Atoms, Electrons, and Lewis-Langmuir Theory.

Nuclear-synthetic.—*See* Nuclear.

Nucleic Acids.—Complex compounds obtained from cell nuclei. They contain carbohydrates, phosphoric acid, purines (*e.g.* guanine, adenine) or pyrimidines (*e.g.* cytosine, thymine).

Nucleins.—Substances found in cell nuclei and having the constitution of salts of a basic protein with a nucleic acid. Also termed *Nucleoproteins.*

Nucleoproteins.—*See* Nucleins.

Nucleosides.—Condensation compounds of one molecule of a carbohydrate with one of a purine or pyrimidine base. *See* Nucleotides.

Nucleotides.—A term proposed in connection with the systematic nomenclature of the nucleic acids. Nucleic acid is a condensation product of phosphoric acid, carbohydrates, and purine or pyrimidine bases. The condensation product of one molecule of phosphoric acid with one each of a carbohydrate and a purine or pyrimidine base is called a *mononucleotide.* As the molecule of nucleic acid contains several phosphoric acid groups with several carbohydrate and basic groups it is considered as a *polynucleotide.*

Nulvalent (Null Valent).—Having no valency, *i.e.* being incapable of chemical combination. An atom whose component system of electrons is stable and which will not lose or gain electrons will be nulvalent. The rare gases are nulvalent.

Nylander's Reagent.—An alkaline solution of bismuth subnitrate and Rochelle salt. It is employed for testing for glucose in urine, etc.

O

o-.—*See* Ortho-.

O-.—Where there is a possibility of groups being attached either to nitrogen or oxygen, etc., the symbol O- is employed to denote attachment to oxygen; *e.g.* O-alkyl in contradistinction to, say, N-alkyl.

Obermayer's Reagent.—A solution of ferric chloride in concentrated hydrochloric acid. Used for detecting indoxyl in urine. If present, indigo is formed.

Oblique (Crystals).—*See* Monoclinic (Crystals).

Occlusion.—Many metals when in a finely divided state will take up or absorb relatively large volumes of certain gases; *e.g.* palladium black will absorb over five hundred times its own volume of hydrogen. The phenomenon is termed occlusion but is now generally regarded as due to formation of solid solutions. *Cf.* Sorption, Adsorption, and Solid Solutions.

Octahedral (Crystals).—*See* Cubic System (Crystals).

Octazones.—Compounds having the general formula

$$R.N : N.NR.N : N.NR.N : N.R,$$

where R is an aryl radical.

Octet Theory.—A name sometimes given to the Lewis-Langmuir theory (*q.v.*).

Octitols.—Octahydric alcohols obtained by reduction of the octoses. *See* Sugars.

Octoses.—Sugars containing eight carbon atoms. *See* Sugars.

Octyl- (Radical).—The normal paraffin group $CH_3(CH_2)_6CH_2-$. The radical of octane.

Odorifores.—Certain groupings in the molecules of odorous substances to which the odour is ascribed. Also termed *osmophores.* They are analogous to the chromophore groups (*q.v.*).

Odorimeter.—*See* Olfactometry.

OEt.—*See* Ethoxy (Ethoxyl) (Radical).

-ol.—*See* Geneva Nomenclature.

-olal.—*See* Geneva Nomenclature.

Olefines.—Acyclic hydrocarbons containing one or more ethylenic double bonds. Those with one have the general formula C_nH_{2n}. Those containing two double bonds are termed diolefines. Ethylene, $CH_2 = CH_2$, is the simplest member of the class. *See* Cyclo-olefines, and Geneva Nomenclature.

Olefinic Terpenes.—*See* Terpenes.

Oleins.—Glycerol esters of oleic acid.

Olfactie.—*See* Olfactometry.

Olfaction.—The study of the relationship between odour and chemical constitution.

Olfactometer.—*See* Olfactometry.

Olfactometry.—Investigation of the degree of sensibility of the olfactory organ carried out in certain specially designed apparatus termed olfactometers and odorimeters; *e.g.* the minimum distance (called an *olfactie*) at which the odour of certain substances such as amyl acetate, terpineol, allyl alcohol, musk, etc., can

be detected may be determined, as may also the weight of odorous substance per c.c. of air at this distance.

-olic.—*See* Geneva Nomenclature.

Oligodynamic Action.—A name given by Nägeli to the toxic action of water containing minute amounts of copper, lead, and other heavy metals on living organisms.

-olone.—*See* Geneva Nomenclature.

OMe.—*See* Methoxy (Methoxyl) (Radical).

-one.—*See* Geneva Nomenclature.

-onic.—*See* Geneva Nomenclature.

Onium compounds.—A name given by Nelson and Falk to those addition compounds in which there is a change in the total number of charges but no change in the algebraic sum of the charges as compared with the simple compounds from which they are produced. Onium compounds are represented by those compounds that contain an atom which exerts additional or partial valencies, such as nitrogen in the ammonium compounds, oxygen in the oxonium compounds, iodine in the iodonium compounds, sulphur in the sulphonium compounds and arsenic in the arsonium compounds; *e.g.* when ammonia combines with hydrochloric acid to give ammonium chloride the total number of charges increases from three to five, thus:—

$$\begin{array}{ccccc} - & & + & & +- \\ -- & & +- & & -+-- \\ NH_3 & + & HCl & \rightarrow & NH_4Cl \end{array};$$

but the algebraic sum of the positive and negative charges on the nitrogen atom is the same. Similar considerations apply in the case of the oxonium, iodonium, sulphonium, and arsonium compounds. *See* these.

Open-chain Compounds.—Acyclic compounds (*q.v.*).

Opposing Reactions.—Reversible or balanced reactions. *See* Chemical Equilibrium, and Mass Action, Law of.

Optical Activity.—A large number of compounds (chiefly organic) when in the liquid state or in solution possess the property of rotating the plane of plane-polarised light. The rotation may be to the right (*dextro-rotation*) or to the left (*lævo-rotation*). Substances rotating the plane to the right are termed *dextro-rotatory* (or *dextro-gyrate*), those to the left *lævo-rotatory* (or *lævo-gyrate*), and the extent of the rotation is termed the *rotatory power*. If α is the angle of rotation, w the weight of substance in grams, v its volume in c.c., and l the length in decimetres of the column of liquid traversed by the light, then the *specific rotation* or *specific rotatory power* for light of the D line (the light of the sodium flame, which is that usually employed) is given by

$$[\alpha]_D = \frac{\alpha \times v}{l \times w}.$$

The term v/w may be substituted by $1/d$ where d is the density. The specific rotation is therefore the angle of rotation produced by one gram of substance in 1 c.c. in a column one decimetre long. The *molecular rotation* is obtained by multiplying the specific rotation by the molecular weight. The hundredth part of this quantity is usually taken in order to avoid large numbers. *See* Asymmetry, Molecular.

Optical Anomaly.—*See* Optical Exaltation.

Optical Antipodes.—*See* Enantiomorphs.

Optical Depression.—The specific (or molecular) refraction of certain compounds, more particularly certain five-membered heterocyclic compounds (*e.g.* the pyrroles and furans) is lower than that calculated. This difference is termed *optical depression*. *See* Molecular Refraction, and Optical Exaltation.

Optical Exaltation.—The value ascribed to the ethylenic double bond in calculating the molecular refraction is increased if that bond is part of a conjugated system. This increase is termed the *optical exaltation* or *optical anomaly*. The difference in the molecular refractions due to this increase is termed the *molecular exaltation* and is denoted by *EM*. The corresponding difference in the specific refraction ($\times 100$) is termed the *specific exaltation* and is denoted by $E\Sigma$. *See* Specific Refraction and Molecular Refraction.

Optical Inverts.—*See* Enantiomorphs.

Optical Inversion.—The conversion of a dextrorotatory into a lævorotatory compound or *vice versa*. The change in the sign of the rotation is termed *optical inversion*; *e.g.* when cane sugar is hydrolysed by sulphuric acid the rotation of the solution changes from dextro to lævo. This is due to the production of fructose, which is more strongly lævorotatory than the glucose (which is simultaneously formed) is dextrorotatory. *See also* Walden Inversion.

Optical Isomerism.—*See* Isomerism, Optical.

Optically Empty (or Void).—A term applied to liquids or solutions which do not show the Tyndall effect. Such liquids are free from highly dispersed particles. *See* Colloidal State.

Optical Resolution.—The separation of the optical isomers of a racemic compound; *e.g.* the separation of the *d*- and *l*- tartaric acids

from racemic tartaric acid by the fractional crystallisation of their cinchonine salts. *See* Enantiomorphs and Racemisation.

Optical Rotation.—*See* Optical Activity.

Optical Rotatory Power.—*See* Optical Activity.

Optical Superposition.—A term applied to the additive property of the optical effects of asymmetric groups. The optical effect of an asymmetric group is independent of, and unaffected by, the presence of other groups.

Order of Reaction.—*See* Reaction Velocity.

Organised Ferments.—*See* Fermentation.

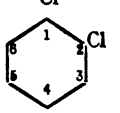
Organogels.—*See* Organosols.

Organometallic Compounds. — Compounds formed by the combination of a metal or metallic salt with organic radicals; *e.g.* zinc methyl, $Zn(CH_3)_2$, lead tetraethyl, $Pb(C_2H_5)_4$, zinc ethyl iodide, $IZnC_2H_5$, etc. *See* Grignard Reagents, Mercurisation, Mercuriated Ketones, and Blaise Reaction.

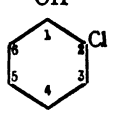
Organosols.—Disperse systems (sols) in which the dispersion medium is an organic liquid such as alcohol or benzene. When the dispersoids are coagulated they form *organogels* (*e.g.* a soap gel in alcohol).

Orsat Apparatus.—An apparatus employed in gas analysis. It consists of a 100 c.c. graduated burette filled with water or mercury, and a series of three absorption vessels. The first contains 30 per cent KOH or NaOH for CO_2 estimation; the second, alkaline pyrogallol or yellow phosphorus for oxygen estimation, and the third an ammoniacal solution of cuprous chloride for the estimation of CO. The 100 c.c. sample of gas is drawn over into these absorption pipettes in series, the diminution in volume after each treatment being read off in the burette to which the gas is returned.

Ortho-.—In disubstituted benzenes substituents in the 1, 2 positions are said to be *ortho* to one another. One group is chosen as occupying the 1 position and the other is then in the *ortho* position to it; *e.g.*,



Orthodichlorbenzene



Orthochlorphenol

There are two ortho positions with respect to any one substituent, viz. the positions 2 and 6. If both these positions are occupied the compound is termed *dimeta-*. The prefix is usually abbreviated to *m-*. *See also* Azines.

(2) There are a number of instances in inorganic chemistry of polyvalent elements forming a series of oxyacids. Those with the highest basicity are termed the *ortho* acids; *e.g.*,

Orthocarbonic

Orthoboric

Orthosilicic

Some of the acids are unstable and are only known in the form of their derivatives; *e.g.* ethylorthocarbonate, $C(OC_2H_5)_4$. Since the acids are derived from the oxides (anhydrides) by addition of water, the ortho acids may be regarded as those which contain the greatest number of molecules of water in combination with one molecule of oxide.

In a similar way the carboxyl group $-C(:O)OH$ of the organic acids may be regarded as derived from the group

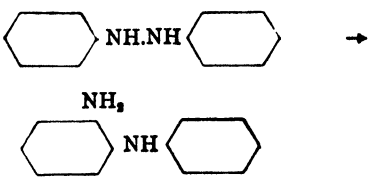
by loss of one molecule of water. Derivatives of compounds containing the above group are known and are also termed ortho acids; *e.g.* orthoformic ester, $H.C(OC_2H_5)_3$; orthoacetic ester, $CH_3C(OC_2H_5)_3$.

Ortho-benzidine Transposition.—A molecular transposition similar to the benzidine transposition (*q.v.*), but in which the two amino groups enter the *ortho* positions instead of the two *para* positions; *e.g.* hydrazonaphthalene gives *oo'*-diaminodinaphthyl.

Orthoquinones.—*See* Quinones.

Orthorhombic (Crystals).—*See* Rhombic (Crystals).

Ortho-semidine Transposition.—The conversion of hydrazobenzenes into the corresponding orthoaminodiphenylamines:—



This change takes place largely in the benzidine transposition if one of the *para* positions is occupied by an alkyl radical R or the group OR.

Osazones.—Compounds containing the grouping

$$\begin{array}{l} -C=N.NHC_6H_5 \\ \quad | \\ -C=N.NHC_6H_5 \end{array}$$

They are formed by the action of phenylhydrazine on 1 : 2-dialdehydes or 1 : 2-diketones or on compounds containing the groups —CO.CHO or —CO.CH_2OH or —CHOH.CHO, such as the sugars. The osazones are of great importance in identifying and characterising the many members of the sugar group.

Osmometer.—An apparatus for measuring osmotic pressure. The various types consist essentially of a closed vessel made of a semi-permeable membrane and carrying a manometer. *See* Osmosis.

Osmophores.—*See* Odorifores.

Osmosis.—If a solution is separated from the pure solvent by a semi-permeable membrane the solvent will diffuse through the membrane into the solution, a process termed *osmosis*. The volume of the solution will thus increase and its level will rise, thus setting up a hydrostatic pressure, termed the *osmotic pressure* The process continues until an equilibrium pressure (maximum hydrostatic pressure) is reached, when no further osmosis takes place. This maximum pressure is attained only if the membrane be entirely impermeable to the solute. The value of the osmotic pressure is proportional to the concentration of the solute; *e.g.* a half gram-molecule of cane sugar in 1,000 grams of water has an osmotic pressure of 12·75 atmospheres at 20° C.; a similar solution containing a gram-molecule has an osmotic pressure of 26·64 atmospheres. The osmotic pressure also varies slightly with the temperature. For very dilute solutions the osmotic pressure is proportional to the molar concentration (*i.e.* inversely proportional to the dilution) and to the absolute temperature, *i.e.*

$$PV = kT,$$

where P is the osmotic pressure, V the dilution in litres, T the absolute temperature, and k a constant which is identical with the gas constant R. The above expression is, in fact, the gas law. It follows that the osmotic pressure of a substance in solution is the same as the gaseous pressure which that substance would exert when in the gaseous state and occupying a volume equal to the volume of the solution and at the same absolute temperature. This fundamental relationship between osmotic and gaseous pressures was first deduced thermodynamically by van't Hoff. It is only true in the case of very dilute solutions of substances which neither associate nor dissociate. Electrolytes give anomalous (high) osmotic pressures, and for these van't Hoff introduced the factor i (termed the van't Hoff Factor), the above expression becoming

$$PV = iRT.$$

The term *osmotic pressure* is used somewhat loosely both for the maximum pressure as deduced from the above law and for that found experimentally. Many theories have been put forward to explain the phenomenon of osmosis. By some it is regarded as due to the bombardment of the walls of the membrane by the solute molecules; by others that it is the result of a difference of free energy, the solvent having a greater free energy than the solution, and thus tending to equalise the energies by diffusion into the solution. Others explain it as a capillarity effect in the pores of the membrane (*i.e.* a surface tension effect). It has also been explained as a chemical attraction between solvent and solute (formation of hydrates). Another theory states that the solvent (which has the higher vapour pressure) is vaporised in the pores of the membrane and condenses in the solution; this process, which is really a distillation, continues until the hydrostatic pressure set up prevents the vaporisation of any more solvent. There are other theories, but so far no entirely satisfactory explanation has been put forward.

Osmotic Pressure.—*See* Osmosis.

Osmotic Work.—The maximum work performed by a solution when diluted from the volume V_1 to the volume V_2. For one gram-molecule of solute it is given by

$$RT\, ln\frac{V_2}{V_1} \quad \text{or} \quad RT\, ln\frac{P_1}{P_2},$$

where P_1 and P_2 are the osmotic pressures at the volumes V_1 and V_2 respectively, R is the gas constant and T the absolute temperature.

Osones.—Compounds containing the grouping —CO.CHO (*i.e.* aldoketoses). They are produced from the osazones (*q.v.*) by hydrolysis with concentrated hydrochloric acid.

Osotetrazones.—Derivatives of the compound

$$\begin{array}{l} CH = N - NH \\ \quad | \qquad\quad | \\ CH = N - NH \end{array}$$

Osotriazoles.—*See* Azoles.

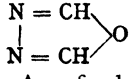
Ostwald's Dilution Law.—*See* Dilution Law.

Ostwald's Stepwise Rule.—*See* Successive Reactions, Law of.

Oudeman's Law.—Landolt-Oudeman's Law (*q.v.*).

Overvoltage.—The voltage required for the deposition of a metal in electrolysis is greater than the single electrode potential for the same ions. This excess voltage is termed *overvoltage.* It is the excess potential required for the discharge of an ion at the electrode over and above the equilibrium potential (electrode potential) of the electrode.

Oxadiazoles (Oxdiazoles).—Derivatives of the compound



Oxal- (Oxalo-).—A prefix denoting the presence of the group —CO.COOH ; *e.g.* oxalacetic acid $HOOC.CO.CH_2COOH$.

Oxalyl- (Radical).—The bivalent group —CO.CO—. The radical of oxalic acid.

Oxamic Acids.—Compounds having the general formula R.NH.CO.COOH, obtained by replacing a hydrogen atom of the amido group of oxamic acid, $NH_2CO.COOH$, by an organic radical R.

Oxamidines.—Amidoximes (*q.v.*).

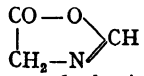
Oxazines.—*See* Azines.

Oxazoles.—*See* Azoles.

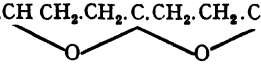
Oxazolidines.—Tetrahydro-oxazoles.

Oxazolines.—Dihydro-oxazoles.

Oxazolones.—Keto-oxazoles ; *e.g.*



Oxetones.—Compounds having the general formula



where R is an alkyl radical or hydrogen.

Oxidases.—A name formerly given to the enzymes which acted by oxidising the substrate. More recent work on these oxidation processes in living organisms has shown that they are of a complex nature and the enzymes proper are the so-called peroxidases (*q.v.*).

Oxidation.—The term oxidation covers several types of chemical reaction. (1) The addition of oxygen to an element or compound irrespective of whether this is carried out directly or indirectly ; *e.g.* mercury to mercuric oxide, $Hg \rightarrow HgO$; barium oxide to the peroxide, $BaO \rightarrow BaO_2$; potassium chloride to the chlorate, $KCl \rightarrow KClO_3$, and this to the perchlorate $\rightarrow KClO_4$; an aldehyde to an acid, $R.CHO \rightarrow R.COOH$; and so on. (2) Withdrawal of hydrogen, *e.g.* hydroquinone to quinone ; alcohols, $R.CH_2OH$, to aldehydes R.CHO, etc. (3) Certain elements exhibit different valencies according to circumstances. Thus sulphur is both tetra- and hexavalent ; phosphorus, ter- and pentavalent ; iron, bi- and tervalent. The conversion of the element from the condition of lower valency to that of higher is an oxidation. Thus ferrous sulphate to ferric sulphate, chromates to dichromates, and manganates to permanganates are oxidation processes. (4) The addition of electronegative elements or groups and, conversely, the withdrawal of electropositive elements or groups, are oxidation processes ; *e.g.* stannous chloride, $SnCl_2$, to stannic chloride, $SnCl_4$, and potassium iodide to iodine.

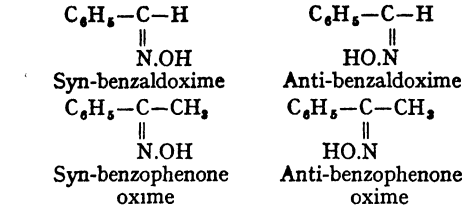
All these types of reaction are fundamentally related. In each case the substance oxidised parts with one or more electrons, thus acquiring the corresponding number of positive charges. If it loses the electrons altogether it becomes an ion ; if not it merely transfers the electron to the atom (*e.g.* O) with which it combines. In general, then, oxidation consists in the acquiring of positive charges by loss of electrons. Since reduction (*q.v.*) is the converse of oxidation it follows that oxidation must always be accompanied simultaneously by reduction.

Oxidimetric Standard.—A substance employed for the standardisation of solutions in the oxidation methods of volumetric analysis ; *e.g.* oxalic acid for standardising potassium permanganate solutions.

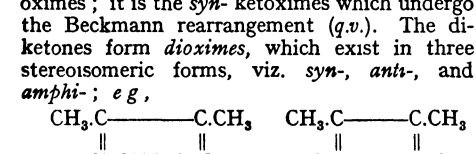
Oxidising Agents.—Substances which bring about oxidation (*q.v.*). Among these may be mentioned oxygen, ozone, the oxy-acids such as nitric and chromic, the per-acids (*q.v.*) and their salts, the peroxides, etc.

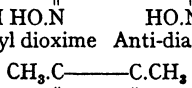
Oximes.—Compounds formed by the action of hydroxylamine, NH_2OH, on aldehydes, ketones, or quinones. Those derived from aldehydes are termed *aldoximes* and have the general formula R.CH : NOH ; *e.g.* benzaldoxime, C_6H_5CH : NOH. Those from ketones are termed *ketoximes* and have the formula R_1R_2C : NOH, or $(R)_2C$: NOH ; *e.g.* benzophenoneoxime, $C_6H_5C(:NOH)CH_3$. The oximes

exist in two stereoisomeric modifications, the *syn-* and *anti-*, thus :—



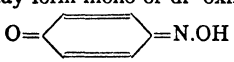
With oximes from symmetrical ketones, such as acetone, only one modification is possible. The *syn-* and *anti-* forms are geometrical isomers and are interconvertible, the conversion of the *syn-* to the *anti-* and *vice versa* being termed *inversion*. The *syn-* oximes are less stable than the *anti-* oximes ; it is the *syn-* ketoximes which undergo the Beckmann rearrangement (*q.v.*). The diketones form *dioximes*, which exist in three stereoisomeric forms, viz. *syn-*, *anti-*, and *amphi-* ; *e g*,



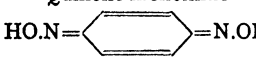


Amphi-diacetyl dioxime

Quinones may form mono or di- oximes ; *e g.*,



Quinone monoxime



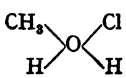
Quinone dioxime

Oximido- (Group).—*See* Oximino- (Group).

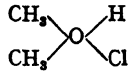
Oximino- (Group).—The group = N.OH. The oxime group. Identical with the isonitroso group. Also termed *oximido* group.

Oxo- (Compounds).—A generic name for all aldehydes and ketones ; *i.e.* compounds containing the characteristic functional groupings RH.C = O, or $R_1R_2C = O$.

Oxonium Compounds.—Compounds in which an oxygen atom functions tetravalent ; *e.g.* methyl alcohol combines with hydrochloric acid to give the compound



Similarly dimethyl ether gives the compound



Dimethylpyrone behaves in a similar manner. The etherates (*q v.*) and pyrylium compounds (*q.v*) are also oxonium compounds. Where the oxygen combines with an acid as in the above formulæ the compounds are referred to as *oxonium salts*. *See* Onium Compounds.

Oxonium Salts.—*See* Oxonium Compounds.

Oxy-.—A prefix employed to denote that a compound contains more oxygen than the compound from which it is formed ; *e.g.* antimony chloride, $SbCl_3$, → antimony *oxy*chloride, SbOCl. The prefix is frequently (wrongly) used to denote *hydroxy*. Thus the organic hydroxyacids are referred to as oxyacids ; the group $—CH_2CH_2OH$ as oxyethyl instead of hydroxyethyl, and so on.

Oxy-acids.—(1) The inorganic acids which contain oxygen, in contradistinction to those which do not, as, *e.g.*, the halogen acids and HCN. (2) The hydroxyacids (*q.v.*). *See* Oxy-.

Oxyamines.—Derivatives of the hypothetical compound $H_3N = O$, *e.g.* $(CH_3)_3N = O$.

Oxygenation.—The absorption or assimilation of oxygen, as, *e g.*, by blood.

Oxygen Capacity (of Blood).—The oxygen capacity of a specimen of blood is defined as the total volume of oxygen at N.T.P. obtainable from the blood after it has been exposed to the air so that its hæmoglobin has been completely oxidised to oxyhæmoglobin.

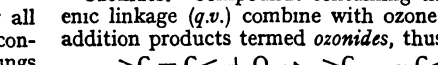
Oxyluminescence.—The emission of light by substances during oxidation by air or oxygen at ordinary temperatures. *See* Chemiluminescence.

Oxymethyl- (Group).—The group $—CH_2OH$.

Oxymethylene- (Group).—The group =CH.OH.

Ozonates.—Compounds formed by the action of ozone on the hydroxides of the alkali metals. The formula $(KOH)_2O_2$ is given to potassium ozonate.

Ozonides.—Compounds containing the ethylenic linkage (*q.v.*) combine with ozone to give addition products termed *ozonides*, thus :—



Diolefinic compounds yield *diozonides* and compounds containing three double bonds give *triozonides*. An interesting example of the latter is benzene triozonide.

Ozonisation.—The treatment of a substance with ozone, generally for the purpose of purify-

ing by the powerful oxidising action of the ozone, as, *e.g.*, in the bleaching of sugar. The term is also employed for the formation of ozone from air or oxygen, and the apparatus in which this is carried out (by means of the silent electric discharge) is termed an *ozoniser*.

Ozoniser.—*See* Ozonisation.

P

p_H, P_H.—The logarithm of the reciprocal of the hydrogen ion concentration, C_H or $[H^+]$, of a solution, *i.e.*,

$$p_H = \log \frac{1}{C_H}.$$

The concentration is expressed in gram-ions per litre. Thus, if $C_H = 10^{-4}$ there will be 0·0004 grams of ionised hydrogen present in a litre of solution and $p_H = 4$. p_H is therefore the index of the concentration with the sign reversed. *See* Indicators.

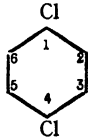
Paal's Method.—Reduction by means of hydrogen and colloidal palladium.

Palmitins.—Glycerol esters of palmitic acid. *See* Glycerides.

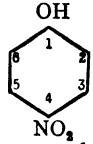
Palmityl- (Radical).—The normal group $C_{15}H_{31}CO$—. The radical of palmitic acid.

Pantochromism.—Variochromism. *See* Chromoisomerism.

Para-.—In disubstituted benzenes, substituents in the 1 : 4 positions are said to be *para* to one another. Usually one substituent is chosen as occupying the 1 position, the other being *para* to it; *e.g.*



Paradichlorbenzene



Paranitrophenol

See Ortho-, Meta-, and Azines.

Paraffenes.—A name by which the cycloparaffins (*q.v.*) are sometimes known.

Paraffins.—The saturated acyclic hydrocarbons. They have the general formula C_nH_{2n+2}. Those containing a straight (normal) chain of carbon atoms are termed *normal* paraffins; *e.g.* *n*-butane, $CH_3CH_2CH_2CH_3$. Those containing the branched chain structure $-C<$, are termed *iso*-paraffins; *e.g.* *iso*pentane, $(CH_3)_2CHCH_2CH_3$. *See* Branched Chains, and Geneva Nomenclature.

Paramagnetic Salt.—A salt of a paramagnetic metal; *i.e.* one whose magnetic permeability is greater than unity. Calcium, chromium, iron, cobalt, nickel, and manganese are paramagnetic, as are also carbon, nitrogen, and oxygen. The ions of these elements are sometimes referred to as paramagnetic ions. *Cf.* Diamagnetic Salt.

Paraquinonoid.—*See* Quinones.

Parasemidine Transposition.—*See* Semidine Transposition.

Partial Pressure.—*See* Dalton's Law.

Partial Valency.—*See* Valency.

Particle Distribution Law (Perrin).—A law for the distribution of the particles of an emulsion. It takes the form

$$\tfrac{4}{3}\pi r^3 g(D-d)h = \frac{RT}{N} ln \frac{n_1}{n_2},$$

where r is the radius of the particles, g the acceleration of gravity, n_1 and n_2 the number of particles per unit volume in two layers at a distance h apart, D the density of the particles and d that of the liquid medium. N is the Avogadro number, T the absolute temperature, and R the gas constant. In the case of highly disperse (colloidal) systems the law is only valid for the layers near the surface.

Partition Coefficient.—*See* Distribution Law.

Partition Law.—*See* Distribution Law.

Passivity.—Certain metals, notably iron, cobalt, and nickel, when treated with oxidising agents such as concentrated nitric acid, chromic acid, or hydrogen peroxide, become much less chemically reactive. They are said to be in the *passive state*, or to exhibit *passivity*. They are restored to their normal reactivity by removing the surface layer, either mechanically by vigorous rubbing or by treatment with a reducing agent. The phenomenon has not yet received a satisfactory explanation, but appears to be connected with the formation of a layer of oxide or of adsorbed oxygen.

Pavy's Method.—The estimation of glucose in urine by means of Fehling's solution and ammonia.

Pectins.—Complex polysaccharoses containing both pentose and hexose units. They are found in fruits, carrots, etc. They are soluble in water, the solutions forming a jelly when treated with alcohol. The gelatinisation of boiled fruit juices is attributed to the presence of pectins.

Pectisation (Pektisation).—Gelation or coagulation of a sol.

Pentadecyl- (Radical).—The normal paraffin group $CH_3(CH_2)_{13}CH_2-$.

Pentavalent.—*See* Valency.

Pentitols.—Pentahydric alcohols obtained from the pentoses by reduction.

Pentosans.—*See* Hemicelluloses.

Pentoses.—Sugars containing five carbon atoms; *e.g.* xylose and arabinose. *See* Sugars.

Peptides.—*See* Polypeptides.

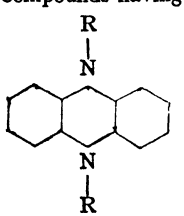
Peptisation.—The transformation of a gel into a sol.

Peptones.—Substances formed in the hydrolysis of proteins by acids or alkalis, together with the proteoses. They are distinguished from the latter by not being precipitated on saturation with ammonium sulphate, and are characterised by the biuret reaction (*q.v.*), giving a pink colour.

Peptonisation.—Peptisation (*q.v.*).

Per-acids.—A name given to certain acids (chiefly inorganic) obtained from the oxyacids by further addition of oxygen. They may be defined as acids which are either (1) formed by the action of H_2O_2 on the oxyacids, or (2) give rise to H_2O_2 when treated with dilute sulphuric acid. Perboric, HO O.BO or $HO.BO_2$; percarbonic, $H_2C_2O_6$; persulphuric, H_2SO_5 (Caro's acid) and $H_2S_2O_8$; and perchromic, $HCrO_5$ and H_3CrO_8, are examples of per-acids. According to the above definition perchloric, periodic, and permanganic acid are not true per-acids. The salts of the per-acids are termed *per-salts*.

Perazines.—Compounds having the structure



where R is an aryl radical; *e.g.* phenyl.

Perfect Gases.—*See* Gas Law.

Perilogic.—*See* Allologic.

Periodic System (Classification, Law).—A numerical relationship between the atomic weights of the elements and their chemical and physical properties. It may be stated thus: the properties of the elements are periodic functions of their atomic weights. Newlands observed in 1864 that if the elements were arranged in ascending order of atomic weight the properties of an element were more or less reproduced in the eighth element from it. Newlands gave to this the name *law of octaves*. The classification was later developed and elaborated by Mendeléef, and is now known by his name. The whole of the elements may be arranged in the form of a table—the periodic table—the horizontal series being termed *periods* and the vertical series or columns *groups*. These eight groups constitute families of closely allied elements. Thus the rare gases form what is termed group O, the halogens fall naturally into another—the seventh—group, and so on with the others. There are certain anomalies in the system. The last column or group (Group VIII) contains what are known as the transitional elements, which do not fit in with the rest of the scheme. They, too, consist of families of related elements; *e.g.* Fe, Co, Ni, form one, and Os, Ir, and Pt form another series of transitional elements.

Peri (Position).—The 1 : 8 positions in the naphthalene nucleus:

Perkin Reaction.—The synthesis of αβ-unsaturated acids of the cinnamic type by treating an aldehyde with an aliphatic acid anhydride and the sodium salt of the aliphatic acid; *e.g.* benzaldehyde when heated to 180° with acetic anhydride and sodium acetate yields cinnamic acid:—

$$C_6H_5CHO \rightarrow C_6H_5CH : CH.COOH.$$

With other aliphatic acids the condensation takes place with the α carbon atom of the acid. Thus propionic anhydride and sodium propionate give α-methylcinnamic acid,

$$C_6H_5CH : C(CH_3)COOH.$$

The aliphatic aldehydes react much less readily. The exact course of the reaction is still a matter of controversy.

Permutites.—Compounds of permutite with metals (metal ions). Alkali permutites are obtained by fusing a mixture of quartz, kaolin, and an alkali carbonate. When these alkali permutites are treated with solutions of various metallic salts the permutite takes up the metal ions, at the same time liberating an equivalent quantity of alkali metal ions.

Peroxidases.—Oxidation processes in the living organism are believed to take place in several stages, viz. (1) an autoxidisable substance, such as an unsaturated fat, takes up atmospheric oxygen, and in so doing it forms,

in part, a peroxide; (2) the oxidation of the other substances present is accomplished by these peroxides, which, however, are only able to act when catalysed by suitable enzymes. These enzymes are termed *peroxidases*.

Peroxides.—Oxides containing a greater proportion of oxygen than the highest of the normal oxides; *e.g.* barium oxide, $BaO \rightarrow$ barium peroxide, BaO_2; sodium oxide, $Na_2O \rightarrow$ sodium peroxide, Na_2O_2; benzoyl peroxide, $(C_6H_5CO)_2O_2$, from benzoic anhydride. *Cf.* Per-acids.

Perrin's Law.—*See* Particle Distribution Law.

Per-salts.—*See* Per-acids.

Persistence of Weight, Law of.—*See* Indestructibility of Matter, Law of.

Petalons.—A name suggested by Chwolson for helium nuclei, which are disc-shaped and make up the positive nucleus of the atoms, according to his theory.

Pettenkoffer's Test.—A test for bile salts. To a thin film of bile a drop of cane sugar solution and a drop of concentrated sulphuric acid are added. A purple colour is produced, due to furfural formed from the sugar by the H_2SO_4 reacting with cholalic acid, $C_{24}H_{40}O_5$.

Ph.—*See* Phenyl.

Phagocytosis.—The destruction of living bacteria by the leucocytes or white corpuscles of the blood.

Pharmacophore Groups.—Certain atomic groupings in the molecules of drugs to which the specific physiological action of the drugs is ascribed. Analogous to the chromophore groups in the dyestuffs.

Phase.—One of the physically distinct and mechanically separable portions of a heterogeneous system, and which may be solid, liquid, or gas. *See* Phase Rule.

Phase Rule.—A general law governing equilibria in heterogeneous systems. It was enunciated by Gibbs in 1874. It applies to all cases of heterogeneous equilibria, both physical and chemical, and, unlike the law of mass action, is independent of the chemical nature or constitution of the substances taking part in the equilibrium. The phase rule is expressed by the equation

$$P + F = C + 2,$$

where P is the number of phases, C the number of components, and F the number of degrees of freedom.

In any system there are three independently variable factors, viz. pressure, temperature, and concentration (or volume). The number of these which must be fixed in order that the system may be exactly defined is termed the number of degrees of freedom of the system; *e.g.* for a gas or vapour two of these variables must be fixed before the third becomes fixed also. A gaseous system of one component therefore has two degrees of freedom; it is *bivariant*. For a one component system, liquid—vapour, if one of the variables is fixed the other two become fixed also; the system has one degree of freedom or is *univariant*. In a one component system, solid—liquid—gas, none of the variables can be altered without one of the phases disappearing altogether. Such a system has no degrees of freedom; it is *invariant*. By the number of components of a system is meant the minimum number of substances taking part in the equilibrium which are necessary in order to define the composition of all the phases. In a system of two components in one phase, *e.g.* a gas mixture, all three variables may be altered independently; the system is therefore *tervariant*. The term *multivariant* is sometimes employed for systems with two or more degrees of freedom.

Phasotropy.—*See* Virtual Tautomerism.

Phenacylidene- (Radical).—The group $C_6H_5COCH=$.

Phenacyl- (Radical).—The group $C_6H_5COCH_2-$,

as, *e.g.*, in diphenacylamine, $(C_6H_5COCH_2)_2NH$.

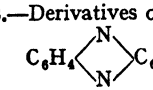
Phenanthrols.—Hydroxyphenanthrenes. Analogous to the phenols and naphthols.

Phenanthryl- (Radical).—The univalent group $C_{14}H_9-$, from phenanthrene. Analogous to phenyl and naphthyl.

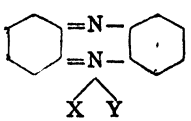
Phenanthrylene- (Radical).—The bivalent group $-C_{14}H_8-$, from phenanthrene. Analogous to phenylene.

Phenates.—Compounds formed by replacing the hydrogen of the OH group in phenols by metals or positive groups; *e.g.* sodium phenate, C_6H_5ONa. Also termed *phenoxides* and *phenolates*.

Phenazines.—Derivatives of phenazine



Phenazonium Compounds.—Compounds of the type



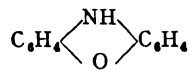
derived from the phenazines, in which XY=HCl C_6H_5I, etc.

Phenolates.—*See* Phenates.

Phenol Ethers.—*See* Ethers.

Phenols.—Aromatic compounds containing OH groups directly attached to nuclear carbon atoms. Those containing two OH groups are termed *diphenols—e.g.* resorcinol (orthodihydroxybenzene); those with three, *triphenols—e.g.* phloroglucinol (*sym*-trihydroxybenzene). The phenols of the naphthalene series are known as *naphthols*, those derived from toluene are termed *cresols*, those from xylene *xylols*, and so on. *Cf.* Alcohols.

Phenoxazines.—Derivatives of phenoxazine



Phenoxides.—*See* Phenates.

Phenoxy- (Radical).—The group $C_6H_5.O-$, from phenol.

Phenylation.—The introduction of the phenyl group into the molecule of an organic compound (usually in the case of substitution in an amino group).

Phenyl- (Radical).—The univalent group C_6H_5-, from benzene. The abbreviation Ph is often employed in formulæ.

Phenylene- (Radical).—The bivalent (ortho, meta, or para) group $-C_6H_4-$.

Phenylhydrazides.—Compounds having the general formula $C_6H_5NH.NHCOR$, where R is an organic radical.

Phenylhydrazones.—Compounds having the general formula $RCH:N.NHC_6H_5$ from the aldehyde R.CHO, or $R_1R_2C:N.NHC_6H_5$ from the ketone R_1R_2CO, and formed by the action of phenylhydrazine $C_6H_5NH.NH_2$. *Cf.* Osazones.

Phenylogic.—*See* Allologic.

Phloroglucinol Test.—A test for pentoses. On adding to a solution of a pentose an equal volume of hydrochloric acid and a little phloroglucinol and heating on the water bath, a cherry-red colour is developed and a precipitate forms which is soluble in cold amyl alcohol, the solution in the alcohol showing an absorption band between D and E.

Phosphatic.—Containing phosphorus; *e.g.* the phosphatic minerals are those containing phosphorus compounds, such as phosphatic chalk which contains phosphorite $(Ca_3(PO_4)_2)$; phosphatic manures, artificial fertilisers, etc.

Phosphazides.—Compounds having the general formula $(R)_3P:N.N:NR$, where R is an alkyl radical. They are derived from phosphazide $H_3P:N.N:NR$.

Phosphazines.—Compounds having the general formula $(R)_3P:N.N:C(R)_2$, where R is an alkyl radical.

Phosphenyl- (Radical).—The bivalent group $C_6H_5.P=$; *e.g.* phosphenyl chloride, $C_6H_5PCl_2$.

Phosphines.—Organic derivatives of phosphine, PH_3; *e.g.* the three methylphosphines, CH_3PH_2 (primary); $(CH_3)_2PH$ (secondary); $(CH_3)_3P$ (tertiary). *Cf.* Amines.

Phosphinic Acids.—Organic compounds containing the group $>PO(OH)$; *e.g.* dimethylphosphinic acid $(CH_3)_2PO(OH)$. They are thus organic derivatives of hypophosphorous acid $H_2PO(OH)$ or $(PH(OH)_2)$.

Phosphinimines.—Compounds having the formula $(R)_3P:NR$, where R is an alkyl radical. They are formed from the phosphazides (*q.v.*) by the action of heat.

Phospholipines.—Lipines (or lipoids) containing phosphorus in the form of phosphoric acid residues united with glyceryl fatty esters and nitrogen bases, such as choline.

Phosphonic Acids.—Compounds having the general formula $R.PO(OH)_2$; *e.g.* benzenephosphonic acid $C_6H_5PO(OH)_2$. *Cf.* Sulphonic acids.

Phosphonium Compounds. — Compounds analogous to the ammonium compounds which contain the phosphonium radical PH_4; *e.g.* phosphonium iodide, PH_4I.

Phosphoproteins.—A group of proteins occurring in milk, eggs, etc., their characteristic being that they contain about one per cent of phosphorus. They are distinguished from the nucleoproteins, which also contain phosphorus, by the fact that the phosphorus in the phosphoproteins is a constituent of one of the amino-acids in the protein and is not contained in a nucleic acid as in the nucleoproteins.

Phosphorescence.—A type of luminescence shown by certain solids. The light emitted is of greater wave length than that of the radiations absorbed. The property is possessed by the sulphides of the alkaline earths, diamond, etc.

Phosphoryl- (Radical).—The tervalent group $OP\equiv$; *e.g.* phosphoryl bromide, $POBr_3$

Photocatalysis.—The velocity of a number of chemical reactions is accelerated when the reacting system is exposed to light; *e.g.* the formation of hydrogen chloride from hydrogen and chlorine; some organic chlorinations; the discharge (*i.e.* oxidation) of iodine ions in solu-

tion to free iodine; the dissociation of carbonyl chloride, $COCl_2$; and so on. Such reactions are said to be *photocatalysed*, and the phenomenon is termed *photocatalysis*. The catalysis is effected by light of a certain wave length, radiations in the blue end of the visible spectrum and the ultra-violet being the most active.

Photocatalysts.—Substances which assist the progress of photochemical reactions; *e.g.* chlorophyll acts as a photocatalyst in the photosynthetic reactions which take place in the green leaves of plants. Again, malachite green acts as a photocatalyst in the formation of formaldehyde from carbonic acid by sunlight. *See* Photosynthesis.

Photochemical Activity.—Light, particularly that of the blue end of the visible spectrum and the ultra-violet, is active both in accelerating chemical reactions which normally proceed slowly (*photocatalysis*) and in initiating some reactions (*photochemical reactions*) and altering the course of others. These processes are due to photochemical activity (actinism). The photographic processes are a result of photochemical activity. *See* Photosynthesis and Photocatalysis.

Photochemical Equivalence, Law of.—A law enunciated by Einstein which states that in a photochemical reaction each molecule must absorb one quantum of energy ($h\nu$) for the reaction to proceed ν is the frequency of the radiation and must have a definite value; *i.e.* one which the molecule can absorb. h is the Planck constant (*see* Quantum Theory)

Photochemical Reaction.—A chemical reaction brought about by radiant energy. *See* Photochemical Activity.

Photochemistry.—That branch of physical chemistry which deals with the action of light (or more strictly, radiant energy other than heat) in relation to chemical change.

Photodynamic Action.—The action of certain substances in bringing about reactions in the cells of organisms which are exposed to light.

Photoelectric Effect.—When certain substances, particularly the metals, are subjected to the action of ultra-violet light they emit a stream of slowly moving electrons (*photoelectrons*), there being a simultaneous absorption of the radiations. The phenomenon is termed the photoelectric effect.

Photoelectrons.—*See* Photoelectric Effect.

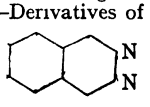
Photoluminescence.—The emission of light by bodies which are subjected to incident external radiations (fluorescence and phosphorescence).

Photolysis.—The process of bringing about a chemical reaction by means of light. *See* Photochemical Activity, and Phototropy.

Photosynthesis.—A synthetic reaction brought about by the action of light. In general, plants will only grow in the presence of sunlight; *i.e.* sunlight is necessary for the building up or synthesis of the products which constitute the living plant, such as the lignocelluloses, sugars, resins, hemicelluloses, pigments, and perfumes. Photosynthesis may also be effected in the laboratory. Thus, when carbonic acid is exposed to light of wave length 200$\mu\mu$ formaldehyde is produced, and with a wave length of 290$\mu\mu$ the formaldehyde polymerises to sugars.

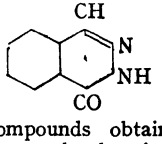
Phototropy (Phototropism).—A number of cases are known in which a substance changes colour when exposed to light, forming an isomeric modification. The change is reversible. Each isomer is sensitive to light of certain wave length and the change will therefore depend on the kind of light to which the substance is exposed; *e.g.* triphenylfulgide changes from orange to brown in sunlight but the colour is restored if the brown isomer is placed in the dark. Cinnamaldehyde semicarbazone exhibits what has been termed *reversed phototropy*. It is a colourless body and shows no visible change in sunlight. If placed in the dark after exposure, however, it changes to yellow, the colour disappearing again in sunlight.

Phthalazines.—Derivatives of phthalazine

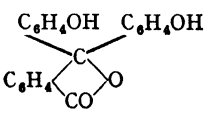


Cf. Cinnolines.

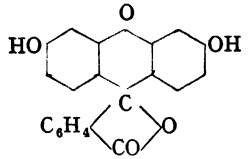
Phthalazones.—Derivatives of the compound



Phthaleins.—Compounds obtained by the condensation of two molecules of a phenol with one of phthalic anhydride; *e.g.* with phenol, phenolphthalein, the well-known indicator, is obtained:—

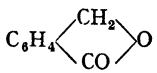


Resorcinol gives the dyestuff fluorescein :—



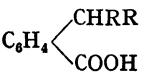
Two of the OH groups condense with formation of a pyran derivative. Compounds of this type are termed *pyronines* and constitute an important class of dyestuffs.

Phthalides.—Derivatives of phthalide



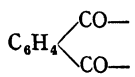
in which one or both hydrogen atoms of the CH_2 group are replaced by organic radicals.

Phthalins.—Compounds having the general formula



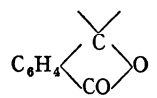
obtained by passing the phthaleins (*q.v.*).

Phthaloyl- (Radical).—The bivalent group



The radical of phthalic acid.

Phthalyl- (Radical).—The bivalent radical

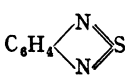


Phyllins.—A general name for the various derivatives of the chlorophylls obtained by the splitting off of carboxyl groups from their molecules but leaving the magnesium intact.

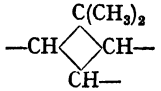
Phytosterols.—Compounds extracted from plants which are similar to the cholesterol of animal tissues. Like cholesterol they are monohydric alcohols of high molecular weight and are soluble in the usual solvents for fats.

Piazines.—Paradiazines, Pyrazines (*q.v.*). *See* Azines.

Piazothiols.—Derivatives of the compound



Picean Ring.—The *gem*-dimethylcyclobutane ring



A nucleus present in the terpenes of the pinene class and some of their products (*e.g.* pinic and pinonic acids) *See* Bridged Rings.

Picolines.—The α-, β-, and γ- methylpyridines.

Picolinium Compounds.—*See* Pyridinium Compounds.

Picolyl- (Radical).—The univalent radical of picoline, $C_5H_4CH_2$— Analogous to benzyl (*q.v.*).

Piezochemistry.—The study of the effect of pressure on chemical properties and reactions.

Piezoelectricity.—The production of electrification by pressure.

Piezoelectron.—According to Chwolson, a disc-shaped electron produced by the ordinary electron being compressed between two petalons (*q.v.*).

Piezometer.—An apparatus for measuring the compressibilities of substances.

Pinacone-pinacoline Rearrangement. — The conversion of pinacones into ketones by the action of dehydrating agents :—

$$(CH_3)_2C(OH)-C(OH)(CH_3)_2 \rightarrow (CH_3)_3CCOCH_3$$

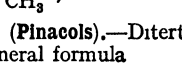
Pinacone — Pinacoline

A methyl group migrates from one carbon to another. Certain glycols of the type

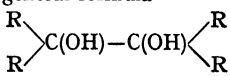
$$R.CH(OH)-C(OH)RR$$

undergo a similar change, the reaction in this case being termed a *semi-pinacoline* rearrangement ; *e.g.*

$$C_6H_5CH(OH)-C(OH)(CH_3)_2 \rightarrow$$



Pinacones (Pinacols).—Ditertiary glycols having the general formula



where R is the same or different alkyl or aryl radicals. They are formed by reduction of the corresponding ketones ; *e g.*

$$CH_3COCH_3 + CH_3COCH_3 \rightarrow$$

Acetone

$$(CH_3)_2C(OH)-C(OH)(CH_3)_2$$

Pinacone

Piotrowski's Test.—The biuret reaction (*q.v.*).

Piperazines.—Hexahydropyrazines. *See* Pyrazines.

Piperidinium Compounds.—Compounds analogous to the pyridinium compounds (*q.v.*) derived from piperidine (hexahydropyridine).

Piperidyl- (Radical).—The univalent radical of piperidine (hexahydropyridine), either N- or C-. Analogous to Pyridyl (*q.v.*).

Pipette.—A glass vessel employed for delivering accurate small volumes of liquid. In its common form it consists of a glass tube with a bulb in the centre and having a graduation mark on the upper part on the tube. There are various modifications for different purposes. *See* Hempel Apparatus.

Pivalyl- (Radical).—The group $(CH_3)_3C.CO-$. The radical of pivalic acid.

Place Isomerism.—*See* Isomerism, Position.

Planck's Constant.—*See* Quantum Theory.

Plane of Symmetry.—*See* Symmetry, Crystal.

Plane-symmetric.—A term sometimes applied to the cis or maleinoid form of geometrical isomers. *See* Isomerism, Cis-trans, and Axial-symmetric.

Plasmolysis.—The result of the shrinking of a plant cell when placed in a hypertonic solution, the protoplasmic layer retreating from the rigid cell wall and leaving a space between the two.

Platinammines.—*See* Ammines.

Platinichlorides.—Chloroplatinates (*q.v.*).

Plauson Mill.—*See* Colloid Mill.

Plumbanes.—Organometallic compounds of lead; *e.g.* lead tetraethyl, $Pb(C_2H_5)_4$; tricyclohexyllead, $(C_6H_{11})_3Pb$.

Plumbates.—Compounds formed by the combination of lead peroxide, PbO_2, with the alkalis; *e.g.* potassium plumbate, K_2PbO_3; calcium plumbate, $CaPbO_3$.

Plumbites.—Metallic derivatives of lead hydroxide, $Pb(OH)_2$; *e.g.* potassium plumbite, $Pb(OK)_2$ or K_2PbO_2.

Poiseuille's Law.—A law for the flow of liquids through capillary tubes, viz.

$$\eta = \frac{\pi g r^4 p t}{8 v l},$$

where g = acceleration of gravity in cms/sec.^{2}; r = radius of the capillary tube in cms; p = pressure in grams/cm^2; t = time of flow in secs.; v = volume of flow in c.cs; l = length of capillary tube in cms; and η = viscosity in c.g.s. units. The reciprocal of η is termed the fluidity.

Polar Compounds.—*See* Polarity (Atoms).

Polarimeter.—An instrument for measuring the angle of rotation of optically active substances. It consists essentially of three parts. In the first, called the *polariser*, the light (monochromatic, such as that from a sodium flame) is plane polarised by means of a Nicol prism. The second part is the observation tube which contains the substance under investigation. In the third part, termed the *analyser*, the light which has passed through the substance in the observation tube is examined by means of another Nicol prism and the angle of rotation measured. *See* Optical Activity.

Polarimetry.—The determination of optical activity by means of the polarimeter.

Polarisation (Electrical).—During the passage of a direct current through many solutions, as in electrolysis, changes occur at the electrodes which alter the superficial nature of these; *e.g.* in many electrolyses hydrogen gas is evolved at the cathode and oxygen at the anode. This amounts to the formation of hydrogen and oxygen electrodes, which at once set up a potential in the opposite direction to that of the current. The effect is termed *polarisation* and the potential set up is referred to as a *back electromotive force* (back e.m.f.).

Polariscope.—Polarimeter (*q.v.*).

Polarity (Atoms).—Substances are classified as *polar* or *non-polar* according as they are or are not affected by the action of an electric field. Thus, *e.g.*, all electrolytes are polar, whereas most organic compounds are non-polar. On the electron theory of the constitution of atoms the difference between the two classes corresponds to a difference in the mode of union of the atoms. For instance, in the polar compound sodium chloride, union of the atoms is considered to take place by the sodium atom giving up its one available electron to the chlorine atom, the sodium atom thus acquiring unit positive charge and the chlorine atom unit negative charge. The atoms are thus united electrostatically. When union is attended by passage of an electron from one atom to another an arrow is employed to denote the *polar bond*. Thus, Na→Cl, or the signs + and − are used: $\overset{+}{Na}\overset{-}{Cl}$. In the non-polar compound methane, on the other hand, union of the atoms is considered to consist in each atom of carbon holding two electrons in common with each of the four hydrogen atoms, the union in this case not being electrostatic. Stark, in his theory,

applies the term polarity to the valency electrons of an atom. Thus the halogens are *unipolar*, oxygen *dipolar*, and so on. *See* Atoms, Lewis-Langmuir Theory, and Induced Alternate Polarity.

Polenski Number.—The difference in temperature between the melting and solidifying points of fats, oils, etc.

Polyatomic.—*See* Atomicity, and Molecules.

Polybasic.—*See* Basicity.

Polychromism.—*See* Chromoisomerism.

Polycyclic.—*See* Cyclic Compounds.

Polydispersoids.—Disperse systems in which the size of the particles of the disperse phase is not uniform, *i.e.* there exist different degrees of dispersion.

Polyhydric.—*See* Alcohols.

Polymericular Weight.—The molecules of the elements polymerise at temperatures near the absolute zero, the copper molecule, for example, consisting of 150 atoms. Its "molecular weight" is therefore $150 \times 63 = 9450$. The term *polymericular weight* has been proposed for these polymerised "molecular weights."

Polymerides.—*See* Polymerism.

Polymerisation.—The process of the formation of a polymer or polymerised product; *e.g.* the polymerisation of acetaldehyde to the trimeride, paraldehyde, by treatment with a drop of concentrated sulphuric acid; and the polymerisation of acetone to the dimeride, diacetone alcohol, by treatment with alkalis. *See* Polymerism.

Polymerism.—The union of two or more molecules of a compound, giving rise to a new compound whose molecular weight is a multiple of that of the single molecule. It is a special case of condensation. The new compound is termed a *polymer* or *polymeride* of the original compound. If two molecules unite the product is termed a *dimeride*; if three, a *trimeride*, *e.g.* acetaldehyde, C_2H_4O, gives the dimeride, aldol, $C_4H_8O_2$, and also a trimeride, paraldehyde, $C_6H_{12}O_3$. Acetylene, C_2H_2, polymerises to benzene, C_6H_6. The term is now more generally reserved for those cases in which the original molecule can be regenerated from the polymer. Unsaturated compounds, and especially the aldehydes, show a strong tendency to polymerise, and in some cases build up very large molecular complexes or aggregates; *e.g.* isoprene, which polymerises to rubber. *See* Condensation.

Polymers.—*See* Polymerism.

Polymethylenes.—*See* Cycloparaffins.

Polymorphism.—*See* Polymorphous.

Polymorphous.—A substance existing in more than one crystalline form is said to be *polymorphous* or the exhibit *polymorphism*.

Polynuclear.—Containing two or more separate ring or cyclic structures in the molecule.

Polyoses.—A name sometimes employed to denote the di- and polysaccharoses (*q.v*) *See* Sugars.

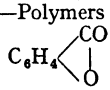
Polypeptides.—Compounds formed by the combination of two or more amino acids so that the carboxyl group of one acid condenses with the amino group of another; *e.g.* two molecules of glycine (aminoacetic acid) give the *dipeptide* glycylglycine, $H_2NCH_2CO.NHCH_2COOH$. Again, glycyl-alanyl-tyrosine,

$$H_2NCH_2CO.NHCH(CH_3)CO.NHCH(CH_2C_6H_4OH)COOH,$$

is a *tripeptide*, and so on. The higher polypeptides show the general properties of the proteins.

Polysaccharoses (Polysaccharides).—Complex carbohydrates of unknown molecular weight. They include the celluloses, hemicelluloses, starches, mucilages, etc. They have not the general properties of the sugars, but yield the latter on hydrolysis; *e.g.* cellulose yields glucose. *See* Hemicelluloses, and Sugars.

Polysalicylides.—Polymers of salicylide,



Polyterpenes.—*See* Terpenes.

Polythionic Acids.—The acids, dithionic, $H_2S_2O_6$; trithionic, $H_2S_3O_6$; tetrathionic, $H_2S_4O_6$, pentathionic, $H_2S_5O_6$; and hexathionic, $H_2S_6O_6$.

Porphyrins.—A general name given to those derivatives of the chlorophylls obtained by splitting off magnesium from the phyllins by the action of acids.

Postion Isomerism.—*See* Isomerism, Position.

Positive (Groups, Radicals).—*See* Electropositive.

Positive Ray Analysis.—The positive rays from a tube containing a gas at a very high vacuum when subjected to a magnetic and electric field and then allowed to fall on a photographic plate, give a photograph of a characteristic parabola. Knowing the amount of deflection produced and the magnitude of the applied forces, as well as the charges on the particles, the masses of the particles can be calculated. The photographic impressions so obtained are termed *mass spectrographs* and the characteristic parabolas *mass spectra*. 0·000004

c.cs. of helium can be detected by this method. A modification of the procedure has led to the discovery of several isotopes (*q.v.*).

Positive Rays.—In a discharge tube, in addition to the cathode rays (*q.v.*), there is a stream of positively charged particles which travel towards the cathode at great speed. By making a suitable opening in the cathode these rays—termed *positive rays*—may be obtained as a pencil or ray behind the cathode. They consist of positively charged molecules.

Potentiometric Titration.—Electrometric titration (*q.v.*), using a potentiometer.

Pr.—*See* Propyl (Group, Radical).

Primary Alcohols.—*See* Alcohols.

Primary Amines.—*See* Amines.

Primary Carbon Atom.—A carbon atom which is united to only one other carbon atom, as in the terminal carbon atoms of the normal hydrocarbons (*q.v.*).

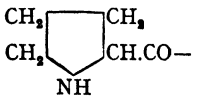
Primary Disazo.—*See* Azo.

Principal Valency.—*See* Valency.

Prismatic (Crystals).—*See* Rhombic (Crystals).

Pro-enzymes.—Inactive precursors of enzymes from which the latter must be transformed before they can act.

Prolyl- (Radical).—The group



The radical of proline (pyrrolidine-2-carboxylic acid).

Propenyl- (Radical).—The univalent group $CH_3CH = CH—$.

Propiono-.—*See* Propionyl (Radical).

Propionyl- (Radical).—The group $CH_3CH_2CO—$

The radical of propionic acid. The prefix *propiono* is sometimes employed for compounds containing this group.

Propylene- (Radical).—The bivalent group $CH_3.CH(—)CH_2—$. *Cf.* Trimethylene- (Radical).

Propyl- (Group, Radical).—The univalent group $CH_3CH_2CH_2—$. The abbreviation Pr is often used in formulæ, and Pr^α or *n*-Pr for the normal propyl group, and Pr^β for the isopropyl group, $(CH_3)_2CH—$.

Propylidene- (Radical).—The bivalent group $CH_3CH_2CH=$.

Prosthetic Group.—A term used in biochemistry to denote a substance in loose combination with a protein and to which the characteristic properties of the combination are due; *e.g.* hæmoglobin contains as prosthetic group, the substance hæmatin, associated with a protein, globin; the colours and general properties of the hæmoglobin are principally due to the hæmatin. Similarly in the nucleoproteins the prosthetic group is the nucleic acid.

Protamines.—A class of proteins occurring in fish sperm, whose characteristics are their strong basicity as compared with other proteins, and the fact that on hydrolysis they yield a large proportion (as much as 80 per cent in some cases) of the diamino-acid, arginine.

Protective Colloids.—Substances in the colloidal state which assist in stabilising a sol by "protective" action against coagulation by electrolytes. *See* Gold Number.

Proteins.—A class of substances occurring in all living matter and containing besides carbon, hydrogen, and oxygen, nitrogen, sulphur, and in some cases phosphorus, iron, etc. They are characterised by yielding mixtures of amino-acids on hydrolysis. The nomenclature adopted for the different classes of proteins is not uniform, but the following classification adopted by the Chemical and Physiological Societies in 1907 is the one in most common use at the present time:—

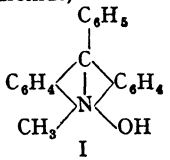
1. Protamines
2. Histones
3. Albumins
4. Globulins
5. Glutelins
6. Gliadins
7. Scleroproteins
8. Phosphoproteins
9. Conjugated Proteins
   - (*a*) Nucleoproteins
   - (*b*) Glucoproteins
   - (*c*) Chromoproteins
10. Protein Derivatives
    - (*a*) Metaproteins
    - (*b*) Proteoses
    - (*c*) Peptones
    - (*d*) Polypeptides.

Proteoclastic (Proteolytic) Enzymes.—That class of enzymes which attack proteins; *e.g.* pepsin and trypsin

Proteoses.—Substances formed in the hydrolysis of proteins with acid or alkali at a later stage than the metaproteins. Half-saturation of the solution so obtained with ammonium sulphate throws down the so-called *primary proteoses*; complete saturation precipitates the *secondary* or *deuteroproteoses*.

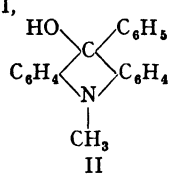
Pseudo-acids.—Certain compounds which, as represented by their ordinary formulæ, are not acids at all, react with bases to give salts, simultaneously undergoing an intramolecular change; *e.g.* phenylnitromethane, $C_6H_5CH_2NO_2$, gives a sodium salt, $C_6H_5CHN(:O)ONa$, the nitro group changing to an isonitro group which has acid properties. Compounds which behaved

in this manner were called by Hantzsch *pseudo-acids*. Similarly certain compounds which are not basic, assume basic properties in the presence of acids, at the same time undergoing a change in constitution; *e.g* phenylmethylacridinium hydroxide,



I

reacts in the free state as if it possessed the constitution II,

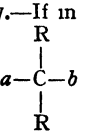


II

whereas with acids it reacts as the true base, I. Hantzsch gave the name *pseudo-bases* to these compounds

Pseudo-alums.—A class of double sulphates similar to the alums (*q.v*), but containing a bivalent metal sulphate in the place of the univalent one. Ferrous magnesium, copper, zinc, and manganese sulphates all form pseudo-alums; *e.g.* $MnSO_4.Al_2(SO_4)_3.24H_2O$. They are not isomorphous with the alums.

Pseudoasymmetry.—If in a compound



R and R are two identical asymmetric groups *having the same spatial arrangement* (*i e.* both + or both −), then the carbon atom C is not asymmetric. If, however, the two groups are oppositely arranged (*i e.* one + and the other −), then the C atom at once becomes asymmetric. This type of asymmetry, which is due to the opposite spatial arrangement of two identical asymmetric groups, is termed *pseudo-asymmetry*. There will be two optically active forms according to whether the two groups, R, are both + or both −, and two inactive forms. Trihydroxyglutaric acid, HOOC.CHOH.CHOH.CHOH.COOH, is an example of a compound which exhibits pseudoasymmetry.

Pseudo-bases.—*See* Pseudo-acids

Pseudoisomerism.—The isomerism of the pseudo-acids and bases. *See* Pseudo-acids.

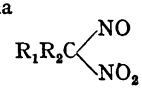
Pseudomerism.—*See* Isomerism, Dynamic.

Pseudomonotropy.—Monotropy may be explained as due to the fact that the transition temperature is above the melting points of the two allotropic forms so that one solid form cannot change into the other. If, however, the transition temperature is below the melting points the phenomenon is termed *pseudomonotropy*. *See* Allotropism.

Pseudomorphs.—Certain substances which change from one crystalline form to another preserve the outer crystalline form of the original, although the internal structure has changed. Thus monoclinic sulphur can be made to change to rhombic while still retaining the needle shape; the latter is, however, made up of smaller crystals of the rhombic modification. Such crystalline forms are termed pseudomorphs.

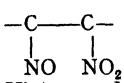
Pseudomucins.—*See* Glucoproteins.

Pseudonitrols.—Compounds having the general formula



See Nitrols.

Pseudonitrosites.—Compounds containing the grouping



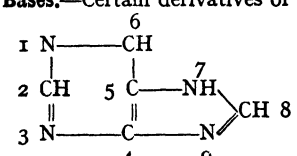
Pseudoracemic Mixtures.—Mixed crystals which contain equal quantities of the two enantiomorphs of an optically active compound.

Pseudo-solutions.—*See* Sols.

Ptomaines.—Basic substances formed during the putrefaction of animal proteins. They include such compounds as neurine and choline.

Pukall Cells.—Vessels made of porous (unglazed) pottery used for filtration of fine precipitates, such as $BaSO_4$, etc.

Purine Bases.—Certain derivatives of purine,



such as uric acid (2 : 6 : 8 : trioxypurine) and adenine (6-aminopurine).

Purpureo-.—A prefix given to the cobalt-ammines having the general formula $Co_2(NH_3)_{11}$.

X_2R_4; *e.g.* bromopurpureocobaltic nitrate, $Co_2(NH_3)_{10}Br_2(NO_3)_4$.

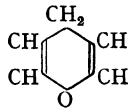
Pustulants.—Drugs having an irritant action sufficiently powerful to cause blisters filled with pus; *e.g.* croton oil.

Pycnometer (Pyknometer).—An apparatus for determining the densities of liquids. In its simplest form it consists of a small glass vessel (about 5–10 c.cs.) whose volume is accurately known. It is filled with the liquid and the whole weighed.

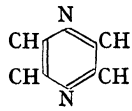
Pyramidal (Crystals).—*See* Tetragonal.

Pyranols.—Hydroxypyrans.

Pyrans.—Derivatives of pyran,



Pyrazines.—Paradiazines, or derivatives of pyrazine,

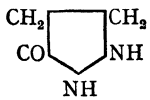


Also termed *piazines*. *See* Azines.

Pyrazoles.—1 : 2 diazoles. *See* Azoles.

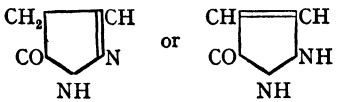
Pyrazolidines.—Tetrahydropyrazoles.

Pyrazolidones.—Ketopyrazolidines; *e.g.*,



Pyrazolines.—Dihydropyrazoles.

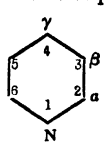
Pyrazolones.—Ketopyrazolines. They contain the nucleus



The drug antipyrine is a phenyldimethylpyrazolone.

Pyridazines.—Orthodiazines. *See* Azines.

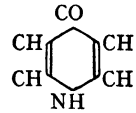
Pyridines.—Derivatives of pyridine



The positions in the pyridine nucleus are designated by numbers or Greek letters as shown.

Pyridinium Compounds.—Compounds derived from pyridine by addition at the nitrogen atom; *e.g.* pyridinium methiodide, $C_5H_5NCH_3I$. Analogous to the ammonium compounds and quaternary bases. The corresponding derivatives of the picolines are termed *picolinium* compounds.

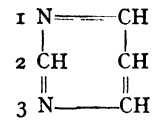
Pyridones.—Ketopyridines; *e.g.*



γ-pyridone

Pyridyl- (Radical).—The univalent radical (N- or C-) of pyridine. Analogous to phenyl.

Pyrimidines.—Metadiazines. Derivatives of pyrimidine :—



e.g. uracil (2 : 6-dioxypyrimidine) and cytosine (2-oxy-6-aminopyrimidine).

Pyro-.—A prefix denoting that a compound is obtained by the action of heat (*i.e.* high temperatures), generally by a process of dry or destructive distillation; *e.g.* pyroracemic (pyruvic) and pyrotartaric acids, which are obtained by the distillation of tartaric acid; pyroligneous acid (crude acetic acid), by the destructive distillation of wood; pyrogallol, by the dry distillation of gallic acid; and so on.

Pyrogenic Reactions.—Chemical reactions brought about by heat, generally at high temperatures.

Pyroligneous.—Derived from wood by its thermal decomposition.

Pyrolysis.—The process of chemical decomposition by heat.

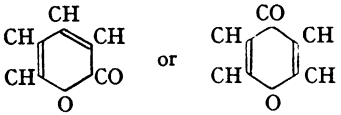
Pyrometers.—Instruments employed for recording temperatures. There are three main classes, viz. (1) thermocouples, which record temperatures by a change in contact potential at a metal | metal junction; (2) resistance pyrometers, in which a change of temperature is recorded by a change in electric current strength, the resistance of a metallic conductor changing with temperature; and (3) optical pyrometers or radiation pyrometers, which are used for measuring the temperatures of bodies, such as furnaces, which are emitting light. The

intensity of the light emitted by another (black) body, such as a carbon filament, is adjusted so that both are of equal intensity. The temperature of a black body emitting light of a definite wave length can be calculated from the radiation law. This is known for the adjusted artificial source and hence the temperature of the other (unknown) body may be obtained.

Pyrometry.—The measurement of temperatures by means of pyrometers.

Pyrometric Cones.—*See* Seger Cones.

Pyrones.—Derivatives of



α-pyrone γ-pyrone

The benzopyrones are termed *chromones*.

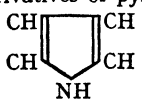
Pyronines.—*See* Phthaleins.

Pyrophoric Action.—The taking fire of finely divided substances in contact with air. This property is characteristic of certain metals, such as iron, nickel, and lead, and the so-called *pyrophoric alloys* (*e.g.* zinc and copper), which are quite stable in the ordinary state. The phenomenon is due to the heat developed by the rapid oxidation, caused by the extensive reaction surface presented by the finely divided metal.

Pyrophoric Alloys.—*See* Pyrophoric Action.

Pyrrodiazoles.—Derivatives of the triazole

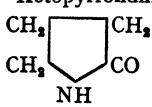
Pyrroles.—Derivatives of pyrrole,



The radical of pyrrol, C_4H_4N-, is termed *pyrryl*. Analogous to phenyl.

Pyrrolidines.—Tetrahydropyrroles.

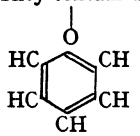
Pyrrolidones.—Ketopyrrolidines; *e.g.*



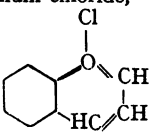
Pyrrolines.—Dihydropyrroles.

Pyrryl- (Radical).—*See* Pyrroles.

Pyrylium Compounds.—Compounds derived from pyran in which the oxygen atom functions tetravalent. They contain the *pyrylium ring*:



e.g. benzopyrylium chloride,



Q

Quadratic (Crystals).—*See* Tetragonal (Crystals).

Quadrimolecular Reaction.—*See* Reaction Velocity.

Quadrivalent.—*See* Valency.

Quadruple Point.—That temperature of a system at which four phases are in equilibrium. If the temperature of a salt solution be lowered sufficiently the salt will begin to be deposited. On lowering the temperature still further a point will ultimately be reached at which the solvent will also separate in the solid form. At this point there will be four phases present, viz. solid salt, solid solvent, solution, and vapour. The system $Na_2SO_4.10H_2O$—Na_2SO_4—solution—vapour has a quadruple point at 32°C. *See* Phase Rule, Cryohydrates, and Freezing Mixtures.

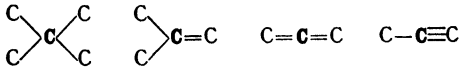
Quantum Theory.—It is considered that radiant energy is not continuous but is discrete or discontinuous, that is to say, exchanges of radiant energy such as that of the continuous spectrum take place by the emission and absorption of a succession of single or separate amounts of energy termed *energy quanta*. The single *quantum* of energy is denoted by ϵ. It is not a fundamental or constant quantity, its value depending on the vibration frequency of the particular radiation; *i.e.* on the vibration frequency of the "resonator" producing the radiation. Thus the infra-red (heat) radiations are produced by the vibration of the atoms and the ultra-violet by that of the electrons, the atoms and electrons being the resonators. The value of the quantum, ϵ, is directly proportionate to the vibration frequency; *i.e.*

$$\epsilon = h\nu,$$

where h is a constant, known as the *Planck Constant*, having the value $6{\cdot}55 \times 10^{-27}$ ergs-seconds. The energy of a resonator must exceed the value ε before the energy can be radiated.

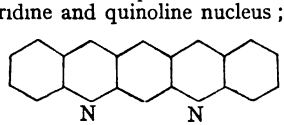
Quaternary (Ammonium) Bases.—Compounds obtained by replacing the four hydrogen atoms in ammonium hydroxide, NH_4OH, by organic radicals. They therefore contain the group $\geqslant N.OH$; *e.g.* tetramethylammoniumhydroxide, $(CH_3)_4N.OH$; choline, $CH_2OH\ CH_2.N(CH_3)_3.OH$; neurine, $CH_2 : CH.N(CH_3)_3.OH$. The N atom may form part of a ring, as in pyridine, quinoline, etc. *See also* Betaines. The corresponding salts—*e.g.* $(CH_3)_4.NI$—are termed *quaternary salts.*

Quaternary Carbon Atom.—A carbon atom all four of whose valencies are saturated by attachment to other carbon atoms. The carbon atom **C** in the following schemes is quaternary :—



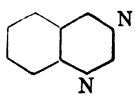
Quaternary (Crystals).—*See* Tetragonal (Crystals).

Quinacridines.—Compounds containing a fused acridine and quinoline nucleus ; *e.g.*

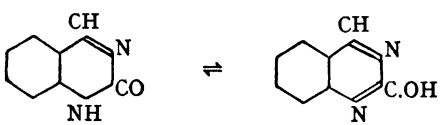


Quinaldinium Compounds.—Compounds analogous to the quinolinium compounds (*q v.*) derived from quinaldine (α-methylquinoline).

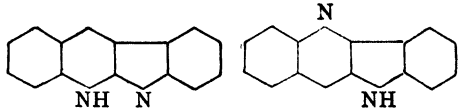
Quinazolines.—Benzopyrimidines (phenomiazines) :—



Quinazolones.—Ketoquinazolines :—

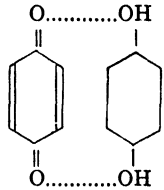


Quindolines.—Compounds obtained by the fusion of a quinoline and indole nucleus. The two classes are termed *peri-* and *ana-* :—



peri *ana*

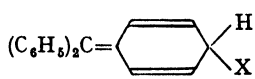
Quinhydrones.—Molecular compounds obtained by the union of one molecule of a quinone with one of the corresponding hydroquinone :—



Similar compounds are obtained from the quinoneimines (*q v.*). The term *meriquinonoid* (or *meriquinoid*) has been given to these compounds.

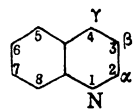
Quino-.—*See* Quinolines.

Quinocarbonium.—A name given by Gomberg to the coloured modifications of triphenylmethyl and its derivatives, to which the following *quinocarbonium* structure has been assigned :—



X is an acid radical.

Quinolines.—Derivatives of quinoline



Substituents in the quinoline nucleus are designated by the numbers or lettering shown. The position 5 is sometimes referred to as the *ana-* position but the term is now little used. Compounds containing the quinoline nucleus sometimes have the prefix *quino*, as, *e.g.*, in quinocyanines, quinoketones, etc.

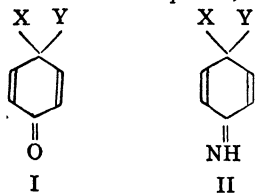
Quinolinium Compounds.—Compounds derived from quinoline by addition at the nitrogen atom ; *e.g.* quinolinium methiodide,

$$C_9H_7N(CH_3)I.$$

Analogous to the pyridinium compounds (*q.v.*).

Quinols.—A class of hemiquinones or half-quinones having the structure I. If the

quinone oxygen be replaced by NH the compounds are known as *iminoquinols*, II.

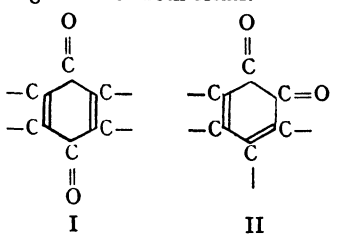


I II

X and Y represent alkyl groups, OH, etc.

Quinolyl (Radical).—The univalent radical of quinoline. Analogous to pyridyl (*q.v.*) and phenyl (*q.v.*).

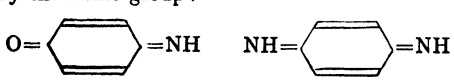
Quinones.—Compounds having the nuclear structure I (*paraquinonoid*) or II (*orthoquinonoid*). The term *quinonoid* (*quinoid*) is employed in general for both forms.



I II

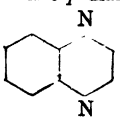
Compounds containing either of the above structures are sometimes termed *holoquinonoid* (*holoquinoid*) to distinguish them from the hemiquinones which contain only one >C=O group. *See* Hemiquinonoid, and Quinols.

Quinonimines.—Compounds derived from the quinones by replacing one (*quinoneimines*) or both (*quinonediimines*) quinone oxygen atoms by the imino group :—



Quinonoid (Quinoid).—*See* Quinones.

Quinoxalines.—Benzo-*p*-diazines :—



Quinquemolecular Reaction.—*See* Reaction Velocity.

Quinquevalent.—*See* Valency.

Quintuple Point.—That temperature of a system at which five phases may exist in equilibrium ; *e.g.* the system $Na_2SO_4.10H_2O$—$MgSO_4.7H_2O$—$Na_2SO_4.MgSO_4.4H_2O$ (astrakanite)—solution—vapour, has a quintuple point at 22° C.

R

R.—*See* Gas Law.

Racemates.—*See* Racemisation.

Racemic Compounds.—*See* Racemisation.

Racemisation.—When many optically active compounds are subjected to the action of heat, alkalis, or acids, they undergo optical inversion, and an optically inactive compound is produced which contains equal quantities of the two optical antipodes. The product is termed a *racemic compound* and the process *racemisation*. Racemic compounds are inactive by external compensation (*q.v.*). Salts of racemic acids are termed *racemates*, but more generally the term refers to the salts of racemic tartaric acid. Some active compounds change spontaneously at ordinary temperatures without the influence of any reagents, a process termed *autoracemisation*. Some other compounds, notably those containing several asymmetric carbon atoms, racemise only to a certain extent (*partial racemisation*) Racemic compounds are designated by *dl-* or *r-*.

Racemism.—The phenomenon of the formation of racemic compounds.

Radiation Hypothesis.—A hypothesis of chemical reactivity which states that a molecule becomes reactive only when its energy content attains a certain critical value. This extra amount of energy—the critical increment, as it is called—is obtained by absorption of radiant energy.

Radicals (Radicles).—Atomic groups which enter into chemical combinations and which possess sufficient stability to persist and pass unchanged through many chemical transformations. Many of them possess pronounced characteristics and properties which are more or less preserved in their various states of combination, as, *e.g.*, the acid radicals SO_4, NO_3, COOH, and the basic radicals NH_4, NH_2, etc. A few of the radicals also exist in the free state as chemical compounds, such as CO, NO, etc. Organic radicals are those containing carbon, such as methyl, CH_3; phenyl, C_6H_5, etc. All radicals are unsaturated ; *i.e.* they possess one or more free valencies. Thus the above organic radicals are univalent, as are

NO_3, NH_2, etc. Methylene and phenylene (*q.v.*) are bivalent, and methinyl and benzenyl (*q.v.*) are tervalent. *See* Free Radicals.

Radioactive Constant.—The number dn of atoms of a radioactive element disintegrating in the time dt is proportional to the number n of atoms present at that time; *i.e.*

$$\frac{dn}{dt} = \lambda n \quad \text{or} \quad n = n_0 e^{-\lambda t},$$

where n_0 is the number of atoms originally present, n the number present after the time t, e the base of the natural logarithms, and λ a constant termed the radioactive constant.

Radioactivity.—A phenomenon observed in the case of certain elements which consists in the spontaneous emission of certain characteristic radiations which possess the property of penetrating solids and producing ionisation in gases. Three distinct kinds of radiation are distinguished, viz. (1) α-rays: these consist of helium atoms carrying two positive charges. They have a velocity in air of about $1{\cdot}5 \times 10^9$ cms. per second and one gram of radium emits about $3{\cdot}5 \times 10^{10}$ of these *α-particles* per second. (2) β-rays: these consist of a stream of electrons having a velocity approaching that of light. (3) γ-rays: these are similar to X-rays but have a somewhat shorter wave length (10^{-9} cms.). The emission of these rays is the result of the breaking up or disintegration of the atoms of the radioactive element The expulsion of the rays, which appears to be uninfluenced by, and entirely independent of, external conditions, gives rise to a whole series of new products, families of new elements or isotopes being obtained from the single original element. Uranium, thorium, and actinium are amongst the best known naturally occurring radioactive elements.

Radioelements.—Elements showing radioactivity (*q.v.*),

Ramsay and Young, Equation of.—*See* Equations of State.

Ramsay and Young, Law of (Boiling Points).—The ratio of the boiling points (on the absolute scale) of chemically related compounds is approximately a constant at all pressures; *i.e.*

$$\frac{(T_a)_{p_1}}{(T_b)_{p_1}} = \frac{(T_a)_{p_2}}{(T_b)_{p_2}} = \text{constant},$$

where $(T_a)_{p_1}$ and $(T_b)_{p_1}$ are the boiling points of the two compounds at the pressure p_1, and $(T_a)_{p_2}$ and $(T_b)_{p_2}$ those at the pressure p_2.

Raoult's Law.—In 1788 Blagden observed that the lowering of the freezing point of water containing a salt in solution was proportional to the amount of salt present (Blagden's Law). In 1848 Babo showed that the relative lowering of the vapour pressure of a solvent due to a substance in solution was the same at all temperatures (Babo's Law). In 1858 Wullner stated that the lowering of the vapour pressure of water by a solute is proportional to the concentration of the solute (Wullner's Law). In 1886 Raoult confirmed these previous observations, and they are now embodied in what is more generally known as Raoult's Law, viz.:

$$\frac{p_0 - p}{p_0} = \frac{n}{N + n},$$

where p_0 is the vapour pressure of the pure solvent, p that of the solution, n the number of molecules of dissolved substance, and N the number of molecules of solvent. Raoult found that when weights of different substances proportional to their molecular weights were dissolved in the same amount of solvent the same lowering of vapour pressure was obtained. The importance of Raoult's law lies in its application to the determination of molecular weights. If a is the weight of solute and m its molecular weight, b the weight of solvent and M its molecular weight, then the number of molecules of solute is proportional to a/m and the number of molecules of solvent to b/M. Since n is very small compared with N the term on the right side of the above equation may be approximated to n/N. Substituting these terms the equation becomes

$$\frac{p_0 - p}{p_0} = \frac{n}{N} = \frac{aM}{bm}$$

Since a, b, and M are known, the value of m may be determined. The value M must be that for the solvent in the gaseous state, the solution must be dilute and the solute non-volatile. In addition to the measurement of vapour pressure, two other methods for determining molecular weights are based upon the above law, viz. the rise or elevation of boiling point (ebullioscopic method) and the lowering or depression of the freezing point (cryoscopic method). Both the elevation of the boiling point and depression of the freezing point are directly proportional to the lowering of vapour pressure. If a grams of solute when dissolved in b grams of solvent lower the freezing point $t°$, then

$$m = K\frac{a}{bt°},$$

where m is the molecular weight of the solute to be determined and K is a constant. K is termed the *molecular depression* of the freezing point and is the depression produced by one gram-molecule of solute. The same expression holds good for the elevation of the boiling point, K in this case being the *molecular elevation* of boiling point, and, of course, having a different value. The practical methods for determining molecular weights in this way are due mainly to Beckmann, who designed special apparatus (particularly the Beckmann thermometer) for carrying out the experimental work. Beckmann's apparatus is still largely in use, but very great accuracy is not attainable by it except in special cases.

Rare Earth Elements.—A family of elements present in certain sparsely distributed minerals known as the rare earths. The elements comprise scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, samarium, gadolinium, terbium, thulium, and ytterbium.

Rare Gases.—The elements argon, helium, neon, krypton, and xenon.

Rational Formulæ.—*See* Formulæ (Chemical).

Reactants.—In a chemical reaction the initial or original molecules between which the reaction takes place are termed the reactants, the new molecules to which they give rise being termed *resultants*. Thus

Reactants → Resultants.

Reaction Isochore.—*See* van't Hoff Isochore.

Reaction Isotherm.—*See* van't Hoff Isotherm.

Reaction Velocity.—The velocity or rate of a chemical reaction at any time, t, from the commencement is proportional to the concentrations of the reacting substances. Reactions are classified into orders and the expressions for the velocities are characteristic for each order. These are as follow :—

(1) *Reactions of the first order. Monomolecular or Unimolecular Reactions.*—These are of the type

A → one or more products.

Only one molecular species takes part. If a is the initial amount of substance and x the amount changed after the time t, then $(a - x)$ is the amount still present (a, x, and $(a - x)$ are expressed as concentrations). The amount dx of substance changed in the time dt is the velocity of the reaction during the small interval of time dt immediately following the time t. Hence

$$\frac{dx}{dt} = k(a - x).$$

k is a constant termed the *velocity constant*. On integration this expression gives

$$k = \frac{1}{t} ln \frac{a}{a - x},$$

which is the expression for first order reactions.

(2) *Reactions of the second order. Bimolecular Reactions.*—These are of the types

A + B → one or more products, or
2A → ,, ,, ,,

Two molecules take part. If a and b are the initial concentrations of the two molecular species and x the amount of each changed after the time t, then

$$\frac{dx}{dt} = k(a - x)(b - x) \quad \text{or}$$

$$k = \frac{1}{(a - b)t} ln \frac{(a - x)b}{(b - x)a}.$$

If $a = b$, then

$$k = \frac{1}{t} \cdot \frac{x}{a(a - x)}.$$

These are the expressions for second order reactions.

(3) *Reactions of the third order. Trimolecular or Termolecular Reactions.*—These are of the types

A + B + C → one or more products
2A + B → ,, ,, ,,
3A → ,, ,, ,,

As before, the velocity is given by

$$\frac{dx}{dt} = k(a - x)(b - x)(c - x).$$

If $a = b = c$, this expression gives on integration

$$k = \frac{1}{2t}\left[\frac{1}{(a - x)^2} - \frac{1}{a^2}\right].$$

Reactions of higher, viz. *quadrimolecular* and *quinquemolecular* in which four and five molecules respectively take part, are extremely rare. The velocity constant is sometimes designated by the kind of reaction taking place; *e.g. hydrolysis constant* in hydrolytic reactions, *esterification constant* in esterifications, and so on. *See* Mass Action, Law of.

Receptors.—A name given by Ehrlich to certain groups supposed to be present in trypanosomes, etc., which have a specific affinity for certain drugs and which "anchor" the drug molecule and render it effective. *See* Anchoring Groups.

Reciprocal Ohm.—The unit of conductivity, 1/ohm. Also termed *mho.*

Reciprocal Proportions, Law of.—The different weights of different elements which combine with the same weight of another element bear a simple ratio to one another. If *a*, *b*, *c*, and *d* are the weights of four different elements which combine with the weight *x* of another element, then *a*, *b*, *c*, *d* are either equal or are simple multiples of one another. Known also as the Law of Equivalent Proportions.

Reciprocal Salt Pairs.—A system of four salts produced by double decomposition from two salts having no common ion,

$$AB + CD = AD + BC;$$

e.g. $NaNO_3 + KCl = NaCl + KNO_3$.

Recoil Atoms.—Radium emanation (the gas niton) is radioactive, one atom expelling one α-particle at very high velocity. The residual atom acquires a velocity in the opposite direction. These residual atoms, which are radioactive disintegration products of the emanation, are termed recoil atoms.

Rectilinear Diameter, Law of.—*See* Cailletet and Mathias, Law of.

Reduced Equation of State.—*See* Corresponding States.

Reducing Agents.—Substances which bring about reduction (*q.v.*). Among the most generally employed may be mentioned hydrogen (especially in presence of finely divided metals), stannous chloride, carbon, sulphur dioxide, formic acid and formates, hydriodic acid, sodium sulphide, zinc dust, titanous chloride, etc.

Reducing Sugars.—Many of the sugars, such as glucose, mannose, lactose, and fructose, have a more or less powerful reducing action, particularly on alkaline solutions of copper and silver salts. This distinguishes them from the non-reducing sugars, such as cane sugar. *See* Sugars.

Reduction.—The term reduction includes several types of chemical reaction, viz.: (1) The addition of hydrogen to an element or compound; *e.g.* $Mg \rightarrow MgH_2$; ethylene, CH_2; CH_2, to ethane, $CH_3.CH_3$; quionone to hydroquinone; aldehydes, R.CHO, to primary alcohols, RCH_2OH; and so on. (2) The withdrawal of oxygen; *e.g.* metallic oxides to the metals; sulphates, MSO_4, to sulphites, MSO_3; and so on. (3) The conversion of an element from a state of higher valency to one of lower valency; *e.g.* ferric, $Fe^{\cdots}$, to ferrous, $Fe^{\cdot\cdot}$; stannic, $Sn^{\cdots\cdot}$, to stannous, $Sn^{\cdot\cdot}$. (4) Processes involving the addition of electropositive or withdrawal of electronegative elements or radicals; *e.g.* iodine is reduced when it forms potassium iodide. Reduction is the exact converse of oxidation (*q.v.*), and all the cases of reduction are fundamentally related. Reduction is the addition or acquiring of one or more electrons, just as oxidation is the corresponding loss of electrons. The formation of an anion or the discharge of a cation are both reduction processes. *See* Oxidation, Electropositive, and Cathodic Reduction.

Reformatsky's Reaction.—The condensation of compounds containing the CO group with α-bromo-aliphatic acids in presence of zinc. The condensation takes place at the CO group, which may be a keto group or part of a COOR (ester) group. The reaction with bromacetic ester takes place according to the following scheme:—

$$>CO + BrCH_2COOEt + Zn \rightarrow >C\begin{matrix}OZnBr\\CH_2COOEt\end{matrix}$$

$$\xrightarrow{H_2O} >C\begin{matrix}OH\\CH_2COOH\end{matrix}$$

Magnesium may be used in place of zinc. A large number of important syntheses have been carried out in this way.

Refractivity (Refraction).—*See* Specific Refraction, and Molecular Refraction.

Refractometer.—An instrument for measuring refractive index. There are several types, among the better-known being the Abbé, Pulfrich, and Butter refractometers.

Refractometry.—The determination of refractive index by means of a refractometer.

Regular (Crystals).—*See* Cubic System (Crystals).

Regulator Mixtures.—A name given to certain mixtures of substances designed to maintain or preserve some constant conditions in a system in which a chemical reaction is taking place, such as the maintenance of the concentration or active mass of a reacting substance; *e.g.* a mixture of the two hydrogen sodium phosphates is employed for keeping the hydrogen ion concentration constant. *See* Buffer Solutions.

Reichert-Meissl (Reichert-Wollny) Value.—The number of c.cs. of decinormal alkali required to neutralise the volatile fatty acids liberated from a fat or oil. The substance is saponified with alcoholic NaOH, the alcohol evaporated off, and the residue (soap) treated with dilute sulphuric acid to liberate the acids. The whole is then subjected to distillation and the distillate titrated with 0·1 N.$Ba(OH)_2$.

Reichl's Test.—A test for proteins. A blue colour is produced on treatment with benzaldehyde and a drop of ferric chloride and concentrated HCl. The coloration is due to the presence of tryptophane.

Reimer's Reaction.—The synthesis of phenol-aldehydes by treating a phenol with chloroform in presence of alkali hydroxide; *e.g.* phenol gives salicylaldehyde :—

$$C_6H_5OH + CHCl_3 + 3NaOH = HO.C_6H_4CHO + 3NaCl + 2H_2O.$$

The *para*hydroxybenzaldehyde is also formed.

Reimer-Tiemann Reaction.—The synthesis of phenol-carboxylic acids by treating a phenol with carbon tetrachloride in presence of alkali hydroxide; *e.g.* phenol gives chiefly the *para*-hydroxybenzoic acid :—

$$C_6H_5OH + CCl_4 + 4NaOH = HO\,C_6H_4COOH + 4NaCl + 2H_2O.$$

Reinsch's Test.—A test for arsenious compounds. When treated with metallic copper and dilute hydrochloric acid they give a grey deposit of copper arsenide. The latter gives a crystalline sublimate of arsenic trioxide on heating.

Relative Asymmetry.—*See* Asymmetry, Relative.

Residual Affinity.—*See* Valency.

Residual Valency.—*See* Valency.

Resistance Capacity.—*See* Cell Constant.

Resolution.—Optical Resolution (*q v.*).

Resorcyl- (Radical).—The univalent radical of resorcinol (1 : 3-dihydroxybenzene). Analogous to phenyl (*q v.*).

Respiratory Quotient.—The ratio of the volume of carbon dioxide given out to the volume of oxygen taken in by a living organism in a given time.

Resultants.—*See* Reactants.

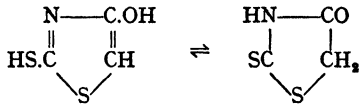
Retger's Law.—A law of isomorphism. Isomorphous substances form mixed crystals, such that the physical properties are a continuous function of the composition.

Reversible Cells.—Electrical cells which, after working and delivering current, can be restored to their original condition by the application of an external current in a direction opposite to that which the cell furnishes.

Reversible Reactions.—*See* Chemical Equilibrium.

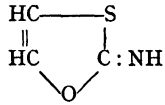
Rhamnosides.—Glucosides which yield rhamnose on hydrolysis; *e.g.* quercitin and frangulin. *See* Glucosides.

Rhodanines.—Derivatives of the compound



Rhode's Test.—A test for proteins. A violet-red coloration is produced on treatment with dimethylaminobenzaldehyde and concentrated H_2SO_4.

Rhodims.—Derivatives of the compound



Rhombic (Crystals).—Crystals which may have as many as three planes of symmetry and three dyad axes of symmetry. Also termed *orthorhombic, trimetric,* and *prismatic.* Iodine, silver nitrate, etc., crystallise in this system. *See* Symmetry, Crystal.

Rhombohedral (Crystals).—*See* Trigonal (Crystals).

Rhythmic Precipitation.—The formation of precipitates in zones by reaction between two compounds in a colloidal medium. The formation of Liesegang Rings (*q v.*).

Riegler's Test.—A test for acetoacetic acid in urine which depends on the fact that iodine reacts with it to give a colourless compound, iodoacetoacetic acid, $CH_3COCHICOOH$. Thus, when a few drops of iodine solution are added to the urine acidified with acetic acid and the mixture shaken with chloroform, no iodine goes up into the chloroform.

Ring-Chain Tautomerism.—*See* Isomerism, Ring-chain.

Ringer's Solution.—A solution of sodium, calcium, and potassium salts containing also a little sodium bicarbonate, used for the histological examination of detached tissues. The concentration used is that required to make a solution isotonic with the cells under examination.

Robin's Law.—If a system in equilibrium is subjected to a change of pressure that change will take place in the system which tends to oppose or nullify the effect of the change of pressure. *See* Le Chatelier's Principle.

Rohrbach's Solution.—A concentrated solution of barium and mercuric iodides having a specific gravity of 3·58. It is employed in the separation of heavy minerals by gravity.

Röntgen Ray Analysis.—X-ray Analysis (*q.v.*).

Röntgen Rays.—X-rays (*q.v.*).

Root-mean-square Velocity.—*See* Maxwell's Distribution Law.

Roseo-.—A prefix given to the cobalt-ammines having the general formula $Co(NH_3)_5.X_3.H_2O$; *e.g.* roseocobaltic nitrate, $Co(NH_3)_5.(NO_3)_3.H_2O$. So called on account of their red colour.

Ross-Jones Test.—A test employed for detecting increase in the globulin content of the spinal fluid.

Rotatory Dispersion (Rotation Dispersion).—The value for the specific rotation of an optically active substance depends on the wave length of the light employed. It is inversely proportional to the square of the wave length, to a close approximation, *i e.*:—

$$[\alpha] = k \cdot \frac{1}{\lambda^2},$$

where λ is the wave length and k a constant. Rotatory dispersion is generally expressed as the ratio of the rotations for the two kinds of light employed. Where the rotation varies inversely as the wave length the dispersion is termed normal. In some cases the rotation varies directly as the wave length. This is termed *anomalous rotatory dispersion.*

Rotatory Power.—*See* Optical Activity.

Rothera's Reaction.—A test for acetoacetic acid in urine. It depends on the fact that in presence of ammonium sulphate and ammonia a solution of sodium nitroprusside produces an intense permanganate colour with that acid.

Rubefacients.—A class of irritants which cause redness of the skin due to dilated blood vessels.

Rudolphi's Formula.—A modification of Ostwald's Dilution Law, viz.:

$$\frac{\alpha^2}{(1-\alpha)\sqrt{v}} = \text{constant}.$$

It is an empirical relationship. *See* Dilution Law.

Runge's Test.—A test for aniline. Extremely dilute solutions of aniline when treated with a drop of bleaching powder solution give a characteristic violet coloration.

S

Saccharates.—Compounds of saccharose (cane sugar) with basic oxides; *e g.*

$$C_{12}H_{22}O_{11}.CaO.2H_2O.$$

Saccharic Acid.—$COOH(CHOH)_4COOH$. Obtained by oxidising glucose with nitric acid.

Saccharides.—*See* Sugars.

Saccharifying Power.—The power of converting starch into sugar.

Saccharimeter.—A name given to two types of apparatus for the estimation of sucrose (cane sugar). One of these instruments is a polarimeter specially designed to read off the amount of sugar directly, and the other is an apparatus in which the sugar is fermented and the carbon dioxide evolved is measured.

Saccharoses (Saccharides).—*See* Sugars.

Salicylides.—Polysalicylides (*q.v.*).

Salicyl- (Radical).—The group

$$o\text{-}HO.C_6H_4-$$

(orthohydroxyphenyl—)

Salicylal- (Radical).—The group

$$o\text{-}HO.C_6H_4\,CH=.$$

Cf. Benzal.

Salicylyl- (Radical).—The group

$$o\text{-}HO\,C_6H_4CO-.$$

The radical of salicylic acid.

Saline.—Containing salt (sodium chloride). The amount or content of salt is termed the *salinity*; *e g.* the salinity of sea water.

Salinity.—*See* Saline.

Salkowski's Reaction.—A test for cholesterin. A chloroform solution of cholesterin when gently shaken with an equal volume of concentrated sulphuric acid, turns red and the neighbouring acid acquires a green fluorescence.

Salol Principle.—The use of drugs such as salol (phenyl salicylate) which hydrolyse slowly in the body to give two active components. Partial salols are those which give the acid or the alcohol (or phenol) as the active substance, but not both.

Salting Out.—The precipitation or separation of a substance from solution, or the coagulation or gelation of a dispersoid, by the addition of a soluble salt. *See* Coagulation, Gels, Isoelectric Point, Hofmeister Series, and Lyotropic Phenomena.

Salts.—Salts are produced by the interaction of an acid and a base Thus,

$$\underset{\text{Acid}}{HA} + \underset{\text{Base}}{BOH} = \underset{\text{Salt}}{BA} + H_2O.$$

Salts may, however, be formed in other ways; *e g.* ammonium chloride is formed by the direct addition of ammonia and hydrochloric acid, $NH_3 + HCl = NH_4Cl$. Again, sodium chloride may be obtained by the action of chlorine on metallic sodium. But in whatever way they are produced they always consist of an acid radical and a basic radical. A salt may therefore be defined as a compound produced by replacing the hydrogen of an acid by an electro-

positive element or group. The composition of a salt depends on the valencies of the acidic and basic radicals. Thus the composition will be represented by BA, BA_2, BA_3, and BA_4, for uni-, bi-, ter-, and quadrivalent bases and a univalent acid radical (monobasic acid); *e.g.* NaCl, $CuCl_2$, $FeCl_3$, $SiCl_4$. Similarly BA, B_2A, and B_3A are salts formed from a univalent basic radical and uni-, bi-, and tervalent acid radicals respectively; *e.g.* NaCl, Na_2SO_4, and Na_3PO_4. Again, B_2A_3 will represent a salt of a tervalent base with a bivalent acid radical; *e.g.* $Al_2(SO_4)_3$; and B_3A_2 that of a bivalent base with a tervalent acid radical; *e.g.* $Ca_3(PO_4)_2$. All the above examples are normal salts (*q.v.*). The salts of the pseudo-acids are termed pseudo-salts. *See* Acid Salts, Basic Salts, Esters, and Molecular Compounds.

Sandmeyer's Reaction.—The formation of aromatic halogen and cyano compounds from the diazo compounds by treating these with the corresponding cuprous salt; *e.g.* diazobenzene chloride gives chlorobenzene with Cu_2Cl_2. *Cf.* Gattermann Reaction.

Saponification.—The hydrolysis of esters by alkalis, the products of hydrolysis being the free alcohol (glycol, phenol, etc.) and the alkali salt of the acid. The term is employed more usually for the hydrolysis of the glycerides (*i.e.* the fats, oils, etc.) by caustic soda or potash, whereby soaps (the Na or K salts of the fatty acids) are formed. Hence the name. It is also employed for the hydrolysis of organic esters in general. *See* Esters, Glycerides, and Hydrolysis.

Saponification Number.—The number of milligrams of potassium hydroxide required for the complete saponification of one gram of fat, oil, wax, etc. A useful constant for the evaluation of these commercial products.

Saponins.—Amorphous, water soluble substances found in plants. On hydrolysis they yield sugars such as glucose and galactose, and substances of unknown composition called sapogenins. Saponin solutions are colloidal, froth readily, and with oils and fats produce very stable emulsions.

Saturated Compounds.—*See* Saturation.

Saturation.—A term employed to denote "completion" of certain physical and chemical reactions. Thus a solution is said to be saturated when it will dissolve no more solute (*i.e.* the amount of solute is a maximum) under the given conditions. Again, a solution of a base is said to be saturated with an acid when that amount of acid is added which just neutralises the base, and *vice versa*. Further, a compound is saturated when it contains no double or triple bonds (*i.e.* unsaturated linkages or valencies). Thus, when ethylene is converted to ethane it becomes saturated. The olefines are unsaturated hydrocarbons. The aldehyde, ketone, cyano, and carboxyl groups are unsaturated. An atom or group is unsaturated if it has any residual or partial valency or residual affinity, but the term is more generally employed in the case of principal or normal valencies.

Saturation Current.—If an ionised gas be placed between two plates, one of which is then electrically charged, a current will flow through the gas from one plate to the other. For very low potential differences between the plates the current is approximately proportional to this applied voltage, but on raising the potential of the plate a point is reached beyond which a further increase in voltage produces no increase in the current. This maximum constant current is termed the *saturation current* and the minimum voltage producing it the *saturation voltage*.

Saturation Voltage.—*See* Saturation Current.

Schardinger's Reaction.—A test used to distinguish fresh from sterilised milk. Fresh milk rapidly reduces methylene blue if an aldehyde such as formaldehyde be present. The milk loses this property on boiling.

Schiff's Bases.—*See* Azomethines

Schiff's Reagent (Solution, Test).—A solution of rosaniline hydrochloride (magenta) decolorised with sulphur dioxide. It is used as a reagent for the detection of aldehydes, which restore the red colour of the magenta.

Schlosing's Reaction.—The preparation of nitric oxide by heating sodium nitrate, ferrous sulphate, and sulphuric acid.

Schmoluchowski's Formula.—A formula connecting Brownian movement (*q.v.*) with the various factors in a disperse system, viz.

$$A = 2{\cdot}37\sqrt{K \cdot \frac{RT}{N} \cdot \frac{t}{\eta r}},$$

where R = gas constant, N = the Avogadro Number, T = the absolute temperature, t = the period of vibration of the particles, η = viscosity of the dispersion medium, r = the radius of the particles, and K is a constant. A is the average length of the path of a particle. Also termed the Einstein-Schmoluchowski formula, since Einstein also deduced the same expression except that he had no factor 2·37.

Scholl Reaction.—Two reactions are known by Scholl's name, viz. (1) nucleus condensation, carried out by heating compounds of the naphthalene and anthracene series in presence of aluminium chloride; and (2) a method for preparing oximes by treating aromatic hydrocarbons with mercury fulminate in the presence of a mixture of anhydrous and hydrated aluminium chloride, *e.g.* benzene gives benzaldoxime,

$$C_6H_6 + \begin{matrix}Cl\\H\end{matrix}\!\!\rangle C{:}NOH \rightarrow C_6H_5CH{:}NOH + HCl$$

Schotten-Baumann Reaction.—The formation of benzoyl derivatives of amines or phenols by treating the latter with benzoyl chloride in presence of a solution of caustic soda or potash. The compound whose benzoyl derivative is required is shaken up with an aqueous solution of NaOH or KOH and a few drops of C_6H_5COCl added. The benzoyl compound separates out.

Schulze's Reagent.—A solution of zinc chloride (sp. gr. 1·8) containing potassium iodide and iodine.

Schweitzer's Reagent.—An ammoniacal solution of cuprous hydroxide. It dissolves cellulose.

Scintilloscope.—*See* Spintharıscope.

Scleroproteins.—*See* Albuminoids and Proteins.

Secondary Alcohols.—*See* Alcohols.

Secondary Amines.—*See* Amines.

Secondary Carbon Atom.—A carbon atom two of whose valencies are attached to carbon; *i.e.* the **C** atoms in

$$>\mathbf{C}\begin{matrix}\diagup C\\\diagdown C\end{matrix} \quad \text{or} \quad C=\mathbf{C}<$$

Secondary Disazo.—*See* Azo (Compounds).

Secondary γ-Rays.—*See* Secondary X-Rays.

Secondary X-rays.—If X-rays be allowed to fall on a substance that substance will give out radiations similar in character to the X-rays. These radiations are termed secondary X-rays, or *scattered radiation*. γ-rays behave in a similar manner. *See* X-Rays and Radioactivity.

Second Ionisation Constant.—A dibasic acid can furnish two hydrogen ions, but it is found in general that at moderate dilutions only one of the hydrogen atoms is ionised, the acid thus behaving as if it were monobasic. The acid dissociates according to the equation

$$AH_2 \rightleftharpoons AH' + H^{\cdot}.$$

As the dilution is increased however, the other atom ionises:—

$$AH' \rightleftharpoons A'' + H^{\cdot},$$

and by the dilution law (*q.v.*)

$$\frac{[A''] \times [H^{\cdot}]}{[AH']} = K.$$

K is the *second ionisation constant*. In many cases the second ionisation is not appreciable until the first ionisation has proceeded to at least fifty per cent, and in some cases to as much as seventy or eighty per cent.

Sedatives.—Substances which arrest vomiting; *e.g.* opium.

Sedimentation.—The settling out of precipitates so that they fall or collect at the bottom. The term is also applied to the method of separation of solids of different densities by treating them with a liquid of suitable density so that one or more of the solids are separated by sinking in the liquid.

Seger Cones.—Small triangular pyramids made of a mixture of aluminium silicate, alkali, and lime. They are employed for the determination of the temperature of furnaces in the ceramic industry. They have melting points depending on their composition, there being a series of cones of melting point range 500–2000° C. They are numbered and the melting point corresponding to each number is known. Consequently, by observing the melting of the cones the temperature of the furnace in which they are placed can be determined.

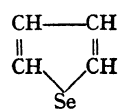
Selective Absorption.—*See* Spectrum, Absorption

Selenazoles.—Azoles (*q.v.*) analogous to the thiazoles but containing a selenium atom in place of one of sulphur.

Selenides.—Selenium compounds analogous to the sulphides; *e.g.* silver selenide, Ag_2Se.

Seleno-.—A prefix employed in the case of certain organic selenium compounds, such as, *e.g.*, selenophenol, C_6H_5SeH.

Selenophenes.—Selenium compounds analogous to the thiophenes; *i.e.* derivatives of selenophen:—



Selenyl- (Radical).—The bivalent radical OSe=; *e.g.* selenyl bromide, $SeOBr_2$.

Semibenzenes.—Compounds having the nuclear structure

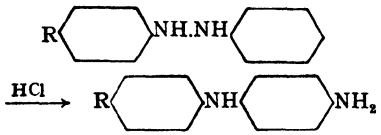
i.e. derivatives of 4-methylene-$\Delta^{2,5}$-cyclohexadiene. R is an alkyl radical (*e.g.* methyl).

Semicarbazones.—Compounds formed by the condensation of semicarbazide, $H_2NCONHNH_2$, with aldehydes and ketones; *e.g.* acetone semicarbazone $(CH_3)_2C : N.NHCONH_2$, and benzaldehyde semicarbazone, $C_6H_5CH : N\ NHCONH_2$.

Semi-colloids.—A name given to a class of substances which are intermediate in their properties between emulsoids and crystalloids, *e.g.* they may diffuse in solution through some membranes but give opalescent solutions and act in some cases as protective colloids. Soaps, casein, certain protein derivatives, etc., belong to this class.

Semicyclic (Methylene Group).—The methylene group CH_2, attached by a double bond to a nuclear carbon atom as in the semibenzenes (*q.v.*).

Semidine (Parasemidine) Transposition.—The isomerisation of the hydrazobenzenes to give the *p*-aminodiphenylamine, thus:—



This is the main reaction where R is an amino or acylamino group. *See* Benzidine Transposition and Orthosemidine Transposition

Semipermeable Membranes.—Membranes which allow of the passage of a solvent but not of a substance dissolved in it; *i.e* they are permeable to solvent but not to solute. It is doubtful whether any membranes are absolutely semipermeable. Many of the natural septa, such as the walls of the cells of living organisms, are more or less semipermeable. A semipermeable membrane is obtained by the precipitation of copper ferrocyanide in the pores of earthenware. This membrane is practically perfect as regards semipermeability, and many classic researches on osmotic pressure have been carried out with it. *See* Osmosis.

Semi-pinacoline Rearrangement.—*See* Pinacone-Pinacoline Rearrangement.

Semi-solute.—A name suggested for substances which are soluble in only one constituent of a mixed solvent; *e.g.* sugar in a water-alcohol mixture.

Serescope.—An apparatus used in conjunction with a microscope for studying the structure of coarse disperse systems.

Sesquiterpenes.—*See* Terpenes.

Sgambati Reaction.—A urinary test depending on the formation of a blue-grey ring on adding fuming nitric acid to urine in a test tube, without mixing. After mixing and allowing to stand several hours and then extracting with chloroform, the latter takes on a bright ruby red colour. The test is given in certain pathological conditions of the urine.

Sialogogues.—Drugs which increase the flow of saliva, *e.g.* mercury.

Siccatives.—Substances used for drying or desiccating. Desiccants. *See* Desiccator.

Side Chains.—Chains of two or more carbon atoms, radicals of the acyclic hydrocarbons and their derivatives, attached to carbon atoms in a ring or nucleus; *e.g.* propylbenzene, $CH_3CH_2CH_2C_6H_5$; cinnamic acid, $C_6H_5CH : CH.COOH$, etc. The term is also sometimes used in the case of branched chains where there is a short chain in a much longer one. *See* Branched Chain Hydrocarbons, *under* Geneva Nomenclature.

Side Chain Theory.—A theory of Ehrlich, associated with the biogen theory (*q.v.*), and proposed in order to account for the production of antitoxins. The toxin molecules are supposed to attach themselves to the side chains of the biogen molecules, the attachment being so firm that these side chains are lost for the ordinary metabolic purposes of the cell and are therefore thrown off. Fresh side chains are formed by the biogen which attach more toxin molecules split off, and so on. Thus the biogen, under the influence of the toxin, is stimulated to the production of side chains, and this stimulation may become so great that excessive numbers of side chains are formed and split off by themselves, the molecules so formed being the antitoxins; *i.e* those side chains in the biogen which attach the toxins to the cell constitute the antitoxin molecules when free in the surrounding serum.

Side Reactions.—*See* Concurrent Reactions.

Siliceous.—Containing silicon, such as the ores or minerals containing silica.

Silico-.—A prefix employed in the case of certain silicon compounds, especially the silicon analogues of some carbon compounds; *e.g.* silicochloroform, $SiHCl_3$, and silicomethane, SiH_4.

Simple Ethers.—*See* Ethers.

Simultaneous Reactions.—Reactions which proceed at the same time in the same reaction system. They may be of three kinds, viz. (1) opposing or balanced reactions, (2) side reactions, and (3) consecutive reactions. *See* Concurrent Reactions, Consecutive Reactions, Chemical Equilibrium, and Mass Action, Law of.

Sita-counter.—A coulometer in which the current is measured by the liberation of mercury (from HgI_2 solution) at the cathode, the volume of mercury so liberated being measured in a graduated glass tube.

Solid Solutions.—A mixture of substances forming a single homogeneous solid phase. The phase may vary in composition within certain limits, as in the case of ordinary liquid solutions. Solid solutions may be formed from a solid and gas, as in the occlusion of gases by charcoal (in which, however, other phenomena also occur), and from solids and solids, as in the case of mixed crystals (*q v*).

Solidus Curve.—*See* Liquidus Curve.

Sols.—Highly disperse systems in a liquid dispersion medium and possessing the general properties of liquids. Also termed colloidal solutions and pseudo-solutions, but the latter term is now little used. If the disperse phase is a liquid the system is termed an *emulsoid sol*, if a solid it is termed a *suspensoid sol*. Sols in which water is the dispersion medium are termed *hydrosols*, those in alcohol *alcosols*. Sols possess the properties characteristic of the colloidal state (*q v.*). *Cf.* Gels.

Solubility.—(1) The property of dissolving in a medium; *i.e* of forming a solution when added to or mixed with a solvent (2) The amount of solute present in a saturated solution under given conditions is termed the solubility of that solute. The graph showing the variation in the concentration of a solute in a saturated solution with variation in temperature is termed the solubility curve. *See* Solution, and Saturation.

Solubility Product.—If a solution is saturated with respect to a binary electrolyte, AB (*e.g.* solution in presence of solid AB), then in the ionic equation

$$[AB] \rightleftharpoons [A'] + [B']$$

the concentration of the undissociated molecules, AB, must be constant. By the dilution law (*q.v.*)

$$\frac{[A'] \times [B']}{[AB]} = \text{constant},$$

therefore $[A'] \times [B']$ must also be constant. The product of the ionic concentrations under these (saturation) conditions is termed the *solubility product* or *ionic product*. If an electrolyte having a common ion, say, A', be added, the concentration of A' will be increased. In order to preserve the equilibrium B' must decrease. To do this some B' will combine with A' to give undissociated AB which will be precipitated, since the solution is already saturated with respect to AB; *e.g.* if KCl be added to a saturated solution of AgCl some of the latter will be precipitated, and if gaseous HCl be led into a saturated solution of NaCl some of this salt will be deposited.

Solute.—*See* Solution.

Solution.—A single homogeneous phase made up of two or more components and whose composition may vary within certain limits. Solutions may exist in the gaseous, liquid, and solid phases. A mixture of gases is a gaseous solution but is not referred to as such. Similarly there are solid solutions (*q v.*). By the term solution is generally understood the liquid phase. The liquid is termed the *solvent* and the substance dissolved in it, the *solute*. By the word solvent is generally meant that component which is present in excess. In the case of miscible or partially miscible liquids two solutions can be obtained, each liquid being in turn solvent and solute according to which is in excess. The term solution is also applied to the process of dissolving a substance in a solvent.

Solution Pressure.—The force which drives a substance into solution. It is the osmotic pressure of a saturated solution of the substance *Cf.* Electrolytic Solution Pressure.

Solvates.—*See* Solvation.

Solvation.—The formation of complexes or molecular compounds by the combination of molecules of solute with molecules of solvent. These molecular or ionic complexes are termed *solvates*.

Solvatochromism.—A term proposed by Hantzsch for the formation of coloured solvates (or unstable molecular compounds) by the combination of certain colourless unsaturated compounds with the solvent. *See* Halochromism.

Solvent.—*See* Solution.

Solvolysis.—A term proposed for reactions carried out in fused salts as media and which are analogous to hydrolysis.

Sorption.—A general term denoting all cases involving more than one of the factors, adsorp-

tion, absorption, diffusion, chemical reaction, electrical effects, surface tension, hydrolysis, double decomposition, and formation of solid and colloidal films. It is sometimes employed to cover all the phenomena formerly designated simply by absorption, but now known to be due to a number of different causes such as those mentioned above.

Space Formulæ.—*See* Formulæ (Chemical).

Space Lattice.—The atoms in a crystal are arranged in a definite symmetrical and geometrical pattern. This spatial arrangement conforms to a system of three sets of intersecting planes, the planes in each set being all parallel to one another. The angles of intersection of the planes differ in different crystal systems; *e.g.* in the cubic system the planes are all equally spaced and at right angles to each other. The atoms occupy the corners of the parallelopipeds produced by the intersection of the imaginary planes and thus form a spatial network of intersecting planes of atoms termed a *crystal or space lattice*. *See* X-ray Analysis.

Spark Spectrum.—*See* Spectrum, Emission.

Specific Conductivity.—*See* Conductivity, Electrical.

Specific Exaltation.—*See* Optical Exaltation.

Specific Magnetic Rotation.—*See* Magnetic Rotation.

Specific Magnetisation.—The specific magnetisation produced on unit surface of a substance is given by

$$\chi = \frac{I}{H.d},$$

where I is the quantity of magnetisation, H the intensity of the magnetic field and d the density of the substance. This quantity × the atomic weight = *atomic magnetisation*, and × molecular weight = *molecular magnetisation*. Atomic magnetisation is independent of the mode of chemical combination. Molecular magnetisation is therefore an additive property. Special values are deduced for double and triple bonds, etc., as in molecular refraction (*q v*).

Specific Refraction.—The refractive index, n, varies with the density and temperature, but the empirical relations (specific refractions) $\frac{n-1}{d}$ (Gladstone and Dale, or n, formula), and $\frac{n^2-1}{n^2+2}.\frac{1}{d}$ (Lorentz and Lorenz, or n^2, formula) are a constant for any given element or compound; d is the density at the temperature at which the refractive index, n, is determined.

Specific Surface.—Surface area per unit volume; *i.e.* S/V, where S is the total surface and V the total volume, both measured in the same system of units.

Specific Volume.—The reciprocal of the density; *i.e.* $1/d$. It is therefore the volume occupied by unit mass.

Spectrograph.—An instrument for producing and photographing spectra. It is essentially a spectrometer fitted with a camera.

Spectrometer.—A spectroscope fitted with special adjustable appliances for the direct measurement of angle of dispersion, wave length of spectral lines and absorption bands, etc. *See under* Spectrum.

Spectrometry.—The measurement of line spectra, absorption spectra, etc., by means of the spectrometer.

Spectrophotometer.—A type of spectrometer employed in the measurement of absorption bands. The source of light is divided, one half passing through the solution or liquid under examination and the other half through an adjustable revolving aperture by means of which its intensity can be altered. The two beams emerge one above the other. The two spectra may thus be adjusted until they are of equal intensity.

Spectroradiometer.—A special type of spectrometer for measuring absorption spectra in the infra-red. *See under* Spectrum.

Spectroscope.—An instrument for producing spectra. It consists essentially of three parts, viz. (1) a collimator in which a thin vertical beam of light is produced, (2) a prism which disperses the light, and (3) an observation telescope furnished with eye piece and cross wires. *See under* Spectrum.

Spectroscopy.—The production and examination of spectra by means of the spectroscope.

Spectrum.—When a beam of white light is passed through a glass or quartz prism it is split up or dispersed into a continuous band of colours, viz. red, orange, yellow, green, blue, indigo, and violet, termed a *continuous spectrum*. That produced from sunlight is the *solar spectrum*. This band of colours is termed the *visible* spectrum since its component parts are visible to the eye. The spectrum, however, extends on both sides. The dark region beyond the red end of the spectrum is termed the *infra-red* and the corresponding dark region beyond the violet, the *ultra-violet*. The follow-

ing are the approximate wave-length ranges of the three regions of the spectrum :—

Infra-red	Visible	Ultra-violet
1000–750	750–400	400–100

all measured in μμ. The infra-red is the region of long wave length (low vibration frequency) and corresponds to heat waves. The ultra-violet is the region of short wave length (high vibration frequency) and corresponds to the chemically active radiations. Any source of light will give a spectrum, but a continuous spectrum is only produced by light made up of all the component waves from the infra-red to the ultra-violet. Monochromatic light will give a spectrum consisting of a single bright line having the colour of the light, the rest of the spectrum being dark. Light made up of several colours will give lines in the spectrum corresponding to these colours.

Spectra are divided into two classes, viz. (1) Emission Spectra, and (2) Absorption Spectra

(1) *Emission Spectra.*—These are produced by incandescent bodies and the spectra consist of a series of bright coloured lines according to the nature or composition of the light. Emission spectra are named according to the method employed to produce the light. Thus there are *flame spectra, arc spectra,* and *spark spectra,* these being produced by heating the substance to incandescence by means of a flame, electric arc, or electric spark discharge respectively. A spectrum consisting of a number of lines is termed a *line spectrum.* In some cases there are a number of lines lying very close together and forming what appear to be coloured bands. These are termed *band spectra.* Line and band spectra are *discontinuous* spectra

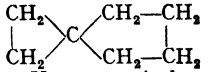
(2) *Absorption Spectra.*—When a beam of white light is passed through a coloured substance or solution it is found that certain portions of the continuous spectrum no longer appear, the spectrum having dark regions or bands. Light of certain wave lengths has been absorbed by the substance. Spectra obtained in this way are termed *absorption spectra.* Similar absorption spectra are also produced in the ultra-violet and infra-red giving *ultra-violet absorption spectra* and *infra-red absorption spectra.* Where the absorption consists of one or more bands it is termed *selective absorption,* but if the absorption is more or less uniform over a considerable region it is termed *general absorption.*

Spectrum Analysis.—*See* Analysis, and Spectrum.

Spinthariscope.—An apparatus for detecting the emission of α-rays from a radioactive substance. It consists essentially of a tube or box with a screen at one end coated with zinc sulphide, and a lens for focussing at the other. The substance is held on a pin in front of the screen and as each α-particle strikes the screen a vivid flash of light is observed. A similar apparatus is termed a scintilloscope.

Spirans.—Spiro compounds (*q.v.*).

Spiro Compounds.—Cyclic compounds which contain *one* carbon atom common to two rings ; *e.g.*



Unsymmetrical Spiroheptane

Spontaneous Combustion.—The rapid combustion and taking fire of substances without the application of external heat or flame. It is due to the heat liberated by some chemical reaction—usually oxidation—which is taking place within the mass of the substance.

Spring's Reaction.—The formation of thiosulphates by treating a mixture of alkali sulphide and sulphite with iodine ; *e.g.*

$$Na_2S + Na_2SO_3 + I_2 = Na_2S_2O_3 + 2NaI$$

Stalagmometer.—An instrument for measuring surface tension by the drop method, the tension being calculated from the drop number.

Standard Cell.—An electrical cell which has a definite and constant voltage. Such cells are not generally employed for supplying current but are used as standards for electrical (e.m.f.) measurements. The commonest standard cells are the Clark cell,

$$Zn \mid ZnSO_4 \mid Hg_2SO_4 \mid Hg$$

and the cadmium or Weston cell

$$Cd \mid CdSO_4 \mid Hg_2SO_4 \mid Hg$$

See Concentration Cell and Electrode Potential.

Standard Solution.—A solution of a reagent the strength of which is accurately known. The strength (*i.e.* concentration) is usually expressed in grams or gram-molecules per litre or cc. *See* Normal Solutions.

Stannates.—Salts of stannic acid, H_2SnO_3 ; *e.g.* sodium stannate, Na_2SnO_3.

Stannichlorides.—Chlorostannates (*q.v.*).

Stannites.—Compounds obtained by dissolving stannous oxide, SnO, or hydroxide, $Sn(OH)_2$, in caustic alkalis ; *e.g.* KOH gives potassium stannite, K_2SnO_2.

Stannonic Acids.—Compounds analogous to the carboxylic acids and having the general formula R.SnOOH, where R is an organic radical; *e.g.* methylstannonic acid, CH_3SnOOH.

Starches.—Polysaccharoses of high molecular weight and having the general formula $(C_6H_{10}O_5)_n$. Most of them, such as ordinary starch and inulin, occur in plant cells, but a few also occur in animals, such as glycogen, which is a product of metabolism in the liver. Starches yield sugars on hydrolysis or fermentation. Thus ordinary potato starch yields maltose or glucose; inulin yields fructose, and glycogen maltose.

Stark Effect.—The resolution of the lines of a positive-ray spectrum into a number of component lines by the action of an intense electric field.

Steam Distillation.—A method of separation or purification of many substances which have an appreciable vapour pressure at 100° C. and which are otherwise more or less difficult to distil owing to high boiling point or to decomposition. A current of steam is blown through the substance suspended or dissolved in boiling water, a mixture of water and substance distilling over. Sometimes superheated steam is employed.

Stearins.—Glycerol esters of stearic acid.

Stearoptenes.—The solid or high boiling constituents of essential oils.

Stearyl- (Radical).—The normal group $C_{17}H_{35}CO-$, the radical of stearic acid.

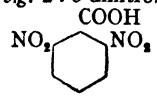
Stepwise Rule (Ostwald's).—*See* Successive Reactions, Law of.

Stereochemistry.—The study of chemical properties and reactions in relation to the arrangement of atoms and molecules in space, or the spatial arrangement of atoms and groups in the molecules of compounds. *See* Asymmetry, Molecular; and under Isomerism. *See also* Formulæ (Chemical), Space.

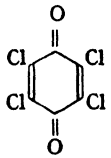
Stereoisomerism.—*See under* Isomerism.

Stereometric Formulæ.—*See* Formulæ (Chemical).

Steric Hindrance.—The reactivity of certain atoms or groups in the molecules of organic compounds is influenced by the proximity of other groups, *e.g.* 2 : 6-dinitrobenzoic acid,



resists direct esterification, whereas benzoic and *o*-nitrobenzoic acids are readily esterified. Similarly the esters of this acid—made indirectly from the silver salts—resist hydrolysis. Again, quinone forms a dioxime, but chloranil (tetrachloroquinone),



does not react with hydroxylamine. There are many other examples of this kind. This stability or inactivity of otherwise reactive atoms or groups is ascribed to the protective or preventive action of the neighbouring groups and the phenomenon is termed steric hindrance. *See* Esterification Law (Victor Meyer's).

Sterols.—Unsaturated monohydric alcohols of high molecular weight occurring in plants and animals. They accompany the fats and are soluble in the same solvents. *See* Phytosterols.

Stibines.—Organic derivatives of stibine, SbH_3; *e.g.* triethylstibine, $Sb(C_2H_5)_3$.

Stibonium Compounds.—Antimony compounds analogous to the quaternary ammonium compounds, in which antimony acts pentavalent; *e.g.* tetraethylstibonium iodide, $(C_2H_5)_4SbI$, and tetraethylstibonium hydroxide, $(C_2H_5)_4Sb.OH$.

Stoichiometry.—The study of the quantitative or numerical relationships of atoms and molecules and the chemical reactions which they undergo; *e.g.* atomic and molecular weights are stoichiometric quantities, and a stoichiometric equation is the ordinary chemical equation which expresses the amounts or weights of the reacting and resulting substances.

Stoke's Reagent (or Fluid).—A solution of ferrous sulphate to which a little tartaric acid has been added followed by ammonia till alkaline. It acts as a reducing agent.

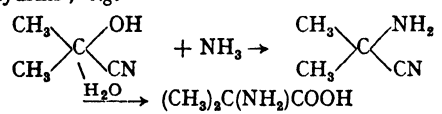
Stopping Power.—The power of substances to reduce the velocity or range of α-particles. It is measured as the ratio of the mass of a column of air to the mass of the substance which causes the same reduction in the velocity, both masses having unit area. The stopping power of an atom may be calculated from the above ratio by multiplying by the ratio of the number of atoms per unit mass of the air and of the substance. Except in the case of the lighter elements the stopping power of an atom is proportional to the square root of the atomic

weight, and is independent of the mode of chemical combination of the atom.

Strain Theory (Baeyer's).—The most stable carbocyclic compounds and the ones occurring most frequently are those containing five or six atoms in the ring. If the carbon atoms are regarded as being at the centres of regular tetrahedra and the four valencies as directed towards the four corners then the angle between any two valencies is 109·5°. A chain of five or six such carbon atoms will form a curve with the two end atoms very near together. Hence the ease of cyclisation of the five and six carbon chains. If the valency directions are bent out of this normal direction a state of strain will be set up leading to instability. This bending or distortion must take place in the rings containing three, four, seven, etc., carbon atoms, so that such rings are more difficult to obtain and are less stable than the five or six membered rings in which the amount of strain is a minimum.

Streaming Method.—The investigation of gaseous chemical equilibria by means of the Deville Hot and Cold Tube (*q.v.*) or modifications of it.

Strecker's Reaction.—The formation of α-aminoacids by the action of ammonia on cyanhydrins; *e.g.*



or, alternatively, of HCN on aldehyde ammonias.

Streptostatic.—A term applied to chromophore groups which constitute part of an acyclic or open chain combination; *e.g.* the azo group. *Cf.* Cyclostatic.

Structural Formulæ.—*See* Formulæ (Chemical).

Structural Isomerism.—*See* Isomerism, Structural.

Styryl- (Radical).—The grouping

$$C_6H_5CH = CH-,$$

from styrene, $C_6H_5CH = CH_2$.

Subatomics.—The chemistry and physics of the constituents of atoms (*i.e.* of electrons and atomic nuclei) and of the changes taking place within the atom, such as radioactive disintegration.

Suberyl- (Radical).—The univalent radical of suberane (cycloheptane).

Sublimation.—The direct transformation from the solid to the vapour phase. *Cf.* Vaporisation.

Submicrons.—Particles observable in the ultramicroscope but invisible in the ordinary microscope. They range in size (diameter) from 0·2μ to 3μμ.

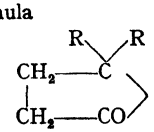
Substituents.—*See* Substitution.

Substitution.—The replacement of an atom or group in the molecule of a compound by some other atom or group. The term is more generally employed for the substitution of hydrogen atoms in organic compounds by atoms of other elements such as the halogens, or by groups or radicals. The entering atom or group is termed the *substituent*. *See under* Ortho, Meta, and Para.

Substrate.—A term employed in enzyme chemistry to denote the substance on which the enzyme acts.

Successive Reactions, Law of.—According to Ostwald if a chemical system is transformed, the transformation proceeds through those systems or stages successively in order of decreasing free energy; *i.e.* increasing stability. Also known as Ostwald's Stepwise Rule.

Succinides.—Derivatives of succinide, having the general formula



where R is an organic radical.

Succinyl- (Radical).—The bivalent group $-CO.CH_2CH_2CO-$. The radical of succinic acid.

Sucroclastic Enzymes.—Enzymes which act by hydrolysing polysaccharoses (*e.g.* starch), sugars (*e.g.* cane sugar), glucosides (*e.g.* amygdalin), etc., yielding sugars. Also termed *glycolytic* enzymes. *See* Enzymes.

Sugars.—A group of carbohydrates characterised by their sweet taste. They all contain primary or secondary (or both) alcoholic OH groups. Many also contain aldehyde or keto groups. The higher members containing only OH groups have the termination *-itol*; *e.g.* erythritol (a *tetritol*), $CH_2OH.CHOH.CHOH.CH_2OH$, and mannitol (a *hexitol*), $CH_2OH(CHOH)_4CH_2OH$. Sugars containing the aldehyde group are termed *aldoses*, and those containing the keto group, *ketoses*. Sugars containing two, three, four, five, six, and seven carbon atoms are termed *bioses*, *trioses*, *tetroses*, *pentoses*, *hexoses*, and *heptoses* respectively.

Those containing both aldehyde and keto groups are termed *aldoketoses* or *ketoaldoses*. The sugars are classified into two divisions, the *monosaccharoses* (*monosaccharides*) and *disaccharoses* (*disaccharides*), or *monoses* and *polyoses*. The former include the aldoses and ketoses containing from two to ten carbon atoms; *e.g. biose* (2), glycollic aldehyde, $CH_2OH\,CHO$; *triose* (3), glyceric aldehyde (glycerose), $CH_2OH.CHOH.CHO$; *tetrose* (4), erythrose, $CH_2OH(CHOH)_2CHO$; *pentose* (5), xylose, $CH_2OH(CHOH)_3CHO$; *hexose* (6), glucose, $CH_2OH(CHOH)_4CHO$, and fructose, $CH_2OH(CHOH)_3COCH_2OH$; *heptose* (7), mannoheptose, *octose* (8), manno-octose; *nonose* (9), gluco-nonose; *decose* (10), gluco-decose.

The disaccharoses have the formula $C_{12}H_{22}O_{11}$ and are also termed bioses. They are condensation products of two molecules of hexose and yield these constituent exoses on hydrolysis. To this class belong cane sugar, maltose, lactose, etc.

Sulphazides.—Compounds having the general formula $R.NH.NH\,SO_2R$; *e.g.*

$$C_6H_5NH.NHSO_2C_6H_5.$$

Sulphillimines.—A name suggested for compounds containing the group $>S:NH$ or $>S:N.R$, *e.g.* $(CH_3)(C_2H_5)S.N\,SO_2C_6H_4CH_3$.

Sulphimides.—Compounds containing the grouping $-SO_2-NH-$.

Sulphinic Acids.—Organic compounds containing the group $-SO_2H(SO.OH)$; *e.g.* benzenesulphinic acid, $C_6H_5SO_2H$.

Sulphinyl- (Radical).—The bivalent group $=SO$.

Sulphion.—The bivalent ion S''. The bivalent ion of hydrosulphuric acid, H_2S.

Sulphofication.—The assimilation and conversion of sulphur in soils, a process analogous to nitrification (*q.v.*).

Sulpho- (Group).—Sulphonic group (*q.v.*)

Sulphonamic Acids.—Compounds having the general formula $R.NH\,SO_3H$ or $R_1R_2\,N\,SO_3H$; *e.g.* phenylsulphonamic acid, $C_6H_5NHSO_3H$.

Sulphonamides (Sulphamides).—Compounds containing the group $-SO_2NH_2$; *e.g. p*-toluenesulphonamide, $CH_3C_6H_4SO_2NH_2$.

Sulphonation.—The introduction of one or more sulphonic groups into the molecule of an organic compound. The products are sulphonic acids.

Sulphones.—Compounds having the general formula $R_1.SO_2.R_2$; *e.g.* phenylethylsulphone, $C_6H_5SO_2C_2H_5$, and diphenylsulphone,

$$C_6H_5SO_2C_6H_5.$$

Disulphones contain two $-SO_2-$ groups, and in cyclic sulphones the SO_2 group forms part of a ring.

Sulphonic Acids.—Compounds containing one or more sulphonic groups. Those containing one are *monosulphonic* acids and sometimes have the prefix *sulpho-*; *e.g.* benzenemonosulphonic acid, $C_6H_5SO_3H$, and sulphobenzoic acid, $HOOC.C_6H_4SO_3H$. Those containing two sulphonic groups are termed *disulphonic* acids; *e.g* anthraquinone-1·5 disulphonic acid (or 1.5-disulphoanthraquinone).

Sulphonic Group.—The univalent group $-SO_3H(-SO_2-OH)$.

Sulphonium Compounds.—Compounds having the general formula $(R)_3S\,X$, where R is an alkyl or aryl radical (the same or different) and X is a negative radical, *e.g* triethylsulphonium iodide, $(C_2H_5)_3SI$ *See* Thetines.

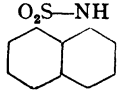
Sulphonyl Chlorides.—Compounds having the general formula $R.SO_2Cl$, where R is an alkyl or aryl radical.

Sulphonyl- (Radical).—The bivalent group $=SO_2$.

Sulphoxides.—Compounds having the general formula $R_1\,SO.R_2$, *e.g.* diphenylsulphoxide, $C_6H_5SOC_6H_5$.

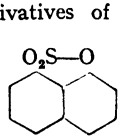
Sulphoxylates.—Salts of sulphoxylic acid, H_2SO_2. These are only known in the form of certain aldehyde and ketone derivatives; *e.g.* formaldehyde sulphoxylate, $HO\,CH_2OSONa$, and acetone sulphoxylate, $(CH_3)_2C(OH)OSONa$. The sodium and zinc salts of the formaldehyde sulphoxylate are extensively used as stripping (reducing) agents in the dyeing industry.

Sultams.—Derivatives of the naphthalene compound



from 1 : 8-naphthylaminesulphonic acid. *Cf.* Lactams.

Sultones.—Derivatives of the naphthalene compound



derived from 1 : 8-naphtholsulphonic acid. *Cf.* Lactones.

Supercooling.—The lowering of the temperature of a liquid below the freezing or solidifica-

tion point without solidification taking place. Such a liquid is in a metastable state with respect to the solid phase. Also termed *superfusion* or *surfusion*. *See* Metastable Equilibrium.

Superfusion.—Supercooling (*q.v.*).

Supersaturation.—In many cases solutions may be obtained which contain more dissolved substance than corresponds to the saturation amount. Such a solution is said to be supersaturated. It is in a state of metastable equilibrium (*q.v.*). If some of the solid solute be added separation of the dissolved solute takes place until normal saturation is reached.

Supertension.—Overvoltage (*q v.*).

Surfusion.—Supercooling (*q v*)

Suspended Transformation.—*See* Metastable Equilibrium.

Suspensoids.—*See* Colloidal State, and Sols.

Svedberg's Law.—A law of Brownian movement. The amplitude of Brownian movement of a particle is directly proportional to the vibration period. If A is the amplitude and *t* the vibration period, then

$$A = k\,t,$$

where *k* is a constant.

Symmetry (Crystal).—Crystalline forms are classified according to their configurations with respect to certain (imaginary) planes, lines, and points The planes are called *planes of symmetry*, the lines *axes of symmetry*, and the points *centres of symmetry* A plane of symmetry is such that it divides the crystal into two parts which bear to one another the relation of object to mirror image As many as nine such planes are possible An axis of symmetry is such that if the crystal is rotated about it there will be a recurrence of similar faces or angles a given number of times for each complete rotation through 360°. If there are two such recurrences the axis is termed a *dyad*, if three a *triad*, if four a *tetrad*, and if six a *hexad* There are no pentad axes. As many as thirteen such axes are possible. If in a crystal, for every face there is a similar face opposite and parallel to it, the crystal is said to have a centre of symmetry In any crystal system there will be a number of possibilities of planes and axes of symmetry. Those crystals possessing the highest number (*i.e.* exhibiting the highest degree of symmetry) are termed *holohedral* or *normal*; *e.g.* in the cubic system such a crystal would possess nine planes, thirteen axes, and one centre of symmetry.

Syn-.—*See* Oximes.

Synthesis.—The formation of a compound from its constituent atoms or from simpler molecules; *e.g.* the formation of water from hydrogen and oxygen, of ammonium chloride from ammonia and hydrochloric acid, of methane from carbon and hydrogen, of benzene from acetylene, of quinoline from glycerol and aniline, etc, etc. *See* Cyanhydrin Synthesis, Gattermann Synthesis, Hoesch Reaction, Reformatsky's Reaction, Knoevenagel's Reaction, and Grignard Reaction The building up of molecules in animals and plants is termed biosynthesis. *See* Photosynthesis

Synthesis, Asymmetric.—*See* Asymmetric Synthesis.

T

T°.—Temperatures on the absolute scale. *See* Absolute Zero.

Tautomerism.—*See* Isomerism, Dynamic.

Tautomers.—*See* Isomerism, Dynamic.

Teichmann's Crystals.—Crystals of hæmin as produced in the usual microscopic test for blood, by boiling a little of the dried blood on a slide with a drop of glacial acetic acid

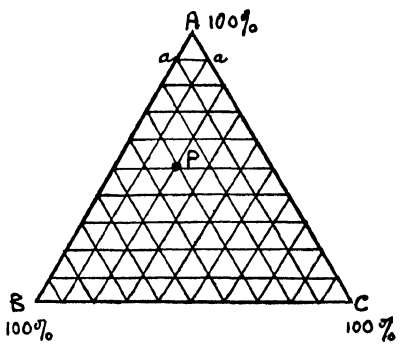
Tensimeter.—An instrument for the determination of vapour pressures.

Terephthalal- (Radical).—The *para* grouping $=HC.C_6H_4\,CH=$

Termolecular Reactions.—*See* Reaction Velocity.

Ternary Electrolytes.—Compounds furnishing three ions in solution.

Ternary Systems.—Systems of three components (*see* Phase Rule). The composition of ternary mixtures is usually represented on an equilateral triangular diagram :—



Each apex represents 100 per cent of each of the

substances A, B, and C respectively. The side AB represents binary mixtures of A and B; the side AC binary mixtures of A and C, and the side BC binary mixtures of B and C. Each side is divided into an equal number of divisions (usually ten, as in the figure) and lines drawn parallel to the sides as shown. Thus the points *a*, *a*, represent 90 per cent A and 10 per cent C (or B), and any point on *aa* will represent 90 per cent A. Similarly with the other sides. Points *within* the triangle represent mixtures of three components Thus the point P represents a mixture of 50 per cent A, 30 per cent B, and 20 per cent C. This method is due to Roozeboom. An earlier method adopted by Gibbs is quite similar, except that the compositions of ternary mixtures are represented as the perpendicular distances from any point (P) to the sides of the triangle, that is, the measurements are made along lines perpendicular to the sides instead of along lines parallel to the sides. Both methods, of course, give the same results.

Terpenes.—A large and important class of organic compounds most of which occur naturally in essential oils and resins. A few are synthetic and are not as yet known to occur in nature. The terpenes have the general formula $(C_5H_8)_n$ and are conveniently classified as follows :—

Hemiterpenes; molecular formula, C_5H_8, *e.g.* isoprene, $CH_3(CH_2)C\,CH : CH_2$. These are not found in nature

Terpenes proper, molecular formula, $C_{10}H_{16}$, *e.g.* geraniol and pinene (*see* Bridged Rings)

Sesquiterpenes; molecular formula, $C_{15}H_{24}$; *e.g.* eudesmol and cadinene.

Diterpenes, molecular formula, $C_{20}H_{32}$; *e.g.* camphorene.

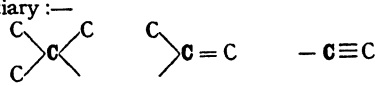
Polyterpenes, molecular formula unknown; *e.g* rubber.

Most of the terpenes are cyclic compounds. The acyclic or open chain terpenes are known as the *olefinic terpenes*.

Tertiary Alcohols.—*See* Alcohols.

Tertiary Amines.—*See* Amines.

Tertiary Carbon Atom.—A carbon atom three of whose valencies are bound to carbon. Thus the carbon atoms **C** in the following schemes are tertiary :—



Tervalent.—*See* Valency.

Tervariant.—*See* Phase Rule.

Tesseral (Tessural) (Crystals).—*See* Cubic System (Crystals).

Tetrad (Axis of Symmetry).—*See* Symmetry, Crystal.

Tetradecyl- (Radical).—The normal paraffin group $CH_3(CH_2)_{12}CH_2-$.

Tetragenic Salt.—A name given by van't Hoff to salts containing four different elements or radicals; *e.g.* kainite, $KCl.MgSO_4$, where the four constituents are K, Cl, Mg, and SO_4. Water of crystallisation is not included.

Tetragonal (Crystals).—Crystals which may have as many as five planes of symmetry and one tetrad and four dyad axes of symmetry. Also termed *symmetrical*, *quaternary*, *quadratic*, and *pyramidal* Nickel sulphate, mercurous chloride, etc, crystallise in this system. *See* Symmetry, Crystal.

Tetrakisazo.—*See* Azo (Compounds).

Tetratomic.—*See* Atomicity and Molecules.

Tetravalent.—*See* Valency.

Tetrazanes.—Derivatives of the unknown compound $NH_2\,NH\,NH\,NH_2$.

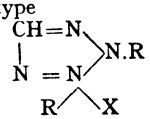
Tetrazenes.—*See* Tetrazones.

Tetrazines.—*See* Azines.

Tetrazo-.—A prefix employed for compounds containing two diazo or azo groups. The terms bisdiazo and bisazo are to be preferred. *See* Azo (Compounds) and Diazo (Compounds).

Tetrazoles.—*See* Azoles.

Tetrazolium Compounds.—Derivatives of tetrazole of the type



in which one of the N atoms acts pentavalent as in the ammonium bases R is an organic radical and X a negative radical, such as Cl or OH.

Tetrazones.—Derivatives of the unknown compound $NH_2\,N\,.\,N.NH_2$; *e.g.* $(C_6H_5)(CH_3)\,N.N : N\,(CH_3)(C_6H_5)$. Also termed *tetrazenes*.

Tetrazotise.—To diazotise both NH_2 groups of a diamine to give a bisdiazo compound. *See* Diazo Reaction.

Tetritols.—*See* Sugars.

Tetroses.—*See* Sugars.

Thermal Analysis.—A method of investigation of the constitution of alloys, due to Tammann, by examination of the rate of cooling of the fused system. The analytical data are deduced from the character of the time-temperature curve. The method is supplemental to

other methods for determining the constitution of alloys.

Thermel.—A name suggested for all thermo-electric temperature measuring instruments (thermoelements). *See* Pyrometers.

Thermite Process.—A process for reducing metals from their oxides. The oxide is mixed with finely divided aluminium and the mixture fired at one point by means of a small flame from burning magnesium or other suitable means. Ignition spreads throughout the mass, the aluminium combining with the oxygen of the metallic oxide, leaving the metal in a pure state. The heat of formation of Al_2O_3 is 300,000 cal. and temperatures of 2000°C. and over are obtained. Thus, in the case of iron oxide the reaction is represented by the equation

$$Fe_2O_3 + 2Al = Al_2O_3 + 2Fe.$$

Also termed the *aluminothermic process* and *Goldschmidt process*. This method for obtaining metals from their oxides is known as *thermo-reduction*.

Thermochemistry.—That branch of physical chemistry which deals with the heat or thermal changes in chemical reactions. *See* Hess' Law, and under Heat of ——. *See also* Equations (Chemical).

Thermocouples.—*See* Pyrometers.

Thermodynamics, Laws of.—*First Law.*—Heat and work are equivalent. That is,

$$W = JQ,$$

where W is the work and Q the heat. J is the conversion factor and is known as Joule's Equivalent (*see* Joule). The law may also be expressed as "The total energy of an isolated system is constant," and "Perpetual motion is an impossibility." *Also known as the Law of the conservation of energy.*

Second Law.—Heat cannot, of itself, pass from a body of low temperature to one of higher temperature. The conversion of heat into work is always accompanied by some other (irreversible) change. Also known as the *Law of the degradation of energy*

Both laws are empirical and founded on experience.

Thermoelements.—Thermocouples. *See* Pyrometers.

Thermoluminescence.—The emission of light by certain substances when gently heated. The phenomenon is exhibited by substances, *e.g.* the alkaline earth sulphides, which have previously been exposed to light. It must not be confused with light produced by heating a substance to a high temperature, as in the case of red hot metals, filament lights, lime-light, etc.

Thermoneutrality.—If two solutions of different electrolytes are mixed there will be no heat change. This is only true in the case of strong electrolytes which may be regarded as completely dissociated.

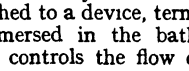
Thermoreduction.—*See* Thermite Process.

Thermoregulator.—*See* Thermostat.

Thermostat.—A constant temperature bath. In its commonest form it consists of a small tank of water the temperature of which is maintained constant by means of a gas burner which is attached to a device, termed a thermoregulator, immersed in the bath and which automatically controls the flow of gas to the burner.

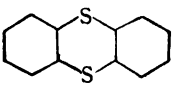
Thermotropy.—The production of coloured isomers of a compound on exposure to heat. The change is reversible, the colourless isomer being regenerated on cooling. *Cf.* Phototropy.

Thetines.—Heterocyclic compounds having the structure



e.g. dimethylthetine (R_1 and $R_2 = CH_3$) is formed from $(CH_3)_2S(OH)CH_2COOH$ by elimination of H_2O.

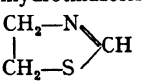
Thianthrenes.—Derivatives of thianthrene



Thiazines.—*See* Azines.

Thiazoles.—*See* Azoles.

Thiazolines.—Dihydrothiazoles; *e.g.*



Thiele-Lachman Reaction.—A test for nitramines (*q.v.*). These give nitrous oxide and nitric acid when treated with concentrated sulphuric acid

Thienyl- (Radical).—The univalent radical, $-C_4H_3S$, of thiophene. Analogous to phenyl and pyrryl. *See* Dithienyls.

Thio-.—A prefix denoting the presence of a sulphur atom in the molecule. The prefix is more usually employed for the sulphur analogues of the oxygen compounds. *See under* various terms below.

Thioacetals.—*See* Mercaptals.

Thio-acids.—Organic acids containing the

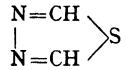
group—CO.SH; *e.g.* thiobenzoic acid, C_6H_5COSH. Compounds containing the group—CS.SH have the prefix *dithio*; *e.g.* dithio-benzoic acid, C_6H_5CSSH. The term is also applied to the sulphur analogues of the inorganic oxyacids; *e.g.* thioarsenious acid, H_3AsS_3; thiocarbonic acid, H_2CS_3, etc. *See* Thionic Acids and Geneva Nomenclature.

Thio-alcohols.—*See* Mercaptans.

Thio-amides.—Compounds of the type $R.CS.NH_2$. *See* Amides.

Thiocarbonylene Compounds.—Sulphur analogues of the carbonylene compounds (*q.v.*). They contain the group C : S in place of C : O.

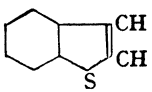
Thiodiazoles.—Five membered ring compounds containing one sulphur, two nitrogen, and two carbon atoms; *e.g.*



Thiodiazolines.—Dihydrothiodiazoles.

Thiols.—*See* Mercaptans.

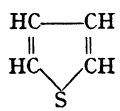
Thionaphthenes.—Derivatives of thionaphthene (benzothiophene)



Thionic Acids.—Compounds containing the group —CS OH. *See* Geneva Nomenclature. *Cf.* Thio-acids.

Thionyl- (Radical).—The bivalent group =SO, as, *e.g.*, in thionyl chloride, $SOCl_2$, and thionylaniline, $C_6H_5N{=}SO$.

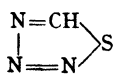
Thiophenes.—Derivatives of thiophene :—



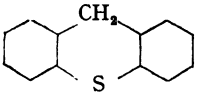
Thiophenols.—*See* Mercaptans.

Thiophosphoryl- (Radical).—The tervalent group ≡PS, as, *e.g.*, in thiophosphoryl chloride, $PSCl_3$.

Thiotriazoles.—Five membered ring compounds containing one sulphur, one carbon, and three nitrogen atoms; *e.g.*



Thioxanthenes.—Derivatives of thioxanthene :—



Thioxenes.—Dimethylthiophenes.

Thrombosis.—The blocking of a blood vessel by the clotting of the blood.

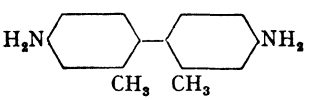
Tiemann-Reimer Reaction.—Reimer-Tiemann Reaction (*q.v.*)

Tintometer.—An instrument employed for the measurement of the depth or intensity and composition of colours, particularly of coloured substances and solutions, by comparison with standard coloured solutions, glass plates, etc.

Titration.—The process of using a standard solution for the estimation of the amount of some substance in another solution. The standard reagent A, reacts quantitatively with the substance B, whose amount has to be determined. The process is carried out by taking a known volume of the solution of B and adding to it gradually the standard solution of A until the reaction is complete. The completion of the reaction is known as the end-point and is generally shown by means of an indicator. This is the fundamental process of volumetric analysis. *See* Analysis, and Indicators

Titration, Electrometric.—*See* Electrometric Titration.

Tolidines.—*pp'*-diaminoditolyls; *e.g.*



Orthotolidine.

Tollen's Reaction.—A test for aldehydes. Metallic silver is deposited on addition of a few drops of ammoniacal silver nitrate to the aldehyde in presence of caustic soda.

Toloxy- (Radical).—The *o-*, *m-*, or *p*-methylphenoxy group, $CH_3C_6H_4.O—$. *Cf* Phenoxy- (Radical)

Toluidides.—Compounds analogous to the anilides (*q.v.*) but derived from toluidine; *e.g.* aceto-*p*-toluidide, $CH_3C_6H_4NHCOCH_3$.

Toluino- (Toluido-) (Radical).—The group $CH_3C_6H_4NH—$ (*o-*, *m-*, *p-*). *Cf.* Anilino- (Radical).

Toluyl- (Radical).—The group $CH_3C_6H_4CO—$ (*o-*, *m-*, *p-*). The radical of the toluic acids.

Toluylene-(Radical).—*See* Tolylene-(Radical).

Tolyl- (Radical).—The group $CH_3C_6H_4$—. The radical of toluene.

Tolylene- (Radical).—The bivalent radical of toluene —$(CH_3)C_6H_3$—. *Cf.* Phenylene. Also termed *toluylene.*

Topochemical.—Reactions which are limited to small contact areas are termed topochemical reactions; *e g.* the precipitation of silver from solution of silver salts during reduction, the separation of carbon from carbon monoxide on metal surfaces, etc.

Topotropy.—Morphotropy (*q v*)

Total Acidity.—Many commercial or crude products contain a mixture of acids, in some cases both free and combined. A titration will take so much standard alkali. This amount of alkali is converted to equivalent of acid calculated in terms of some particular acid and termed the total acidity; *e g.* crude pyroligneous acid will give a total acidity in terms of acetic acid

Toxins.—The toxins are poisonous substances produced by bacteria during their growth in the tissues. In living animals they cause the production of substances from the blood plasma which counteract the effect of the bacterial toxins, and which are therefore called *antitoxins*

Trans.—*See* Isomerism, Stereo-.

Transference Number.—*See* Transport Numbers

Transitional Elements.—*See* Periodic System

Transition Cell.—In a Clark Cell,

$$Zn \mid ZnSO_4 \mid Hg_2SO_4 \mid Hg,$$

the zinc sulphate is present as the heptahydrate, $ZnSO_4\,7H_2O$ Above 39° this undergoes transition into the hexahydrate, the cell now having a lower e m f. Consequently if two cells, one of each of the above, be connected up a current will be obtained A cell such as this in which a difference of potential is produced by the transition of one of the materials of the cell is termed a transition cell.

Transition Interval.—The stability of a double salt in contact with its solution at a given temperature will depend on the relative solubilities of the two constituent salts at that temperature. That temperature at which a double salt begins to be formed from a solution of the two simple salts is the transition temperature, and at some other temperature the double salt will be completely stable in presence of a saturated solution of the constituent salts, *i.e.* the water will no longer decompose it partially into the two salts. In other words, a double salt when dissolved in water to saturation will suffer decomposition over a range of temperature in order to satisfy the equilibrium conditions of the system. This temperature range, which is the interval between the transition point and the temperature of complete stability, is termed the *transition interval.* *See* Transition Point.

Transition Point.—That temperature at which two solid phases are in equilibrium in the absence of the vapour phase. At temperatures below this point one only of the phases is stable and it passes over into the other, at temperatures above the transition point; *e.g* the transition point of rhombic and monoclinic sulphur is 95·5°, monoclinic being the stable form above, and rhombic below, that temperature. Similarly the system

$$Na_2SO_4.10H_2O \rightleftharpoons Na_2SO_4 + 10H_2O$$

has a transition point at 33°, the decahydrate decomposing into the anhydrous salt at that temperature. Some double salt hydrates have transition points, decomposing into the constituent salts above the transition point, these salts recombining to form the double salt below this temperature, other double salts are only formed above the transition point, the two separate salts forming the stable phase below the transition temperature.

Transmutation.—The interconversion of the elements. The aim of the alchemists was to transmute the base metals (lead, etc.) into gold. In a sense the formation of the radioactive degradation products is a process of transmutation, but so far no controlled transmutation of one element into another has been accomplished.

Transpiration (Gases).—The flow of gases through capillary tubes.

Transport Numbers.—If a current is passed through an electrolyte the fraction $\frac{v}{u+v}$ is carried by the anions and the fraction $\frac{u}{u+v}$ by the cations, where v and u are the migration velocities of the anion and cation respectively. These two fractions are termed the *transport numbers* (*Hittorf numbers, Transference numbers*) of the anion and cation respectively. They are also represented by n and $1-n$. These quantities are determined by measuring the fall in concentration of the electrolyte at

the cathode and anode respectively. Thus

$$\frac{\text{Fall in conc. at cathode}}{\text{Fall in conc. at anode}} = \frac{n}{1-n}.$$

See Ionic Mobility and Ionic Conductivity.

Triad (Axis of Symmetry).—*See* Symmetry, Crystal.

Triads.—(1) An obsolete name for trivalent elements.

(2) According to van Laar's classification of tautomers, triads are those groupings in which the atom migrates from the first to the third of three atoms. That is, the two fixed atoms in the chain between which the wandering atom oscillates are separated by a third atom. *Cf* Dyads.

Trianthrimides. — Trianthraquinonylamines. They have the general formula AQ—NH—AQ —NH—AQ, where AQ is the anthraquinonyl radical, $C_{14}H_7O_2$.

Triatomic.—*See* Atomicity, and Molecules.

Triazanes.—Hydrazoamino- compounds. They contain the group $-NH\ NH.NH_2$.

Triazenes.—Compounds containing the group $-NH.N{=}N-$; *e.g.* dimethyltriazene, $CH_3NH.N : NCH_3$.

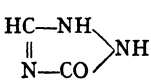
Triazines.—*See* Azines.

Triazo Compounds.—Compounds having the general formula $R.N\langle^{N}_{\|}{}^{}_{N}$, where R is an organic radical. *See* Azides.

Triazo Group.—The group $-N\langle^{N}_{\|}{}^{}_{N}$ *See* Azides.

Triazoles.—*See* Azoles.

Triazolones. — Ketotriazoles ; *e.g* 1 : 3-triazolone



Tribasic.—*See* Basicity.

Triboluminescence.—The emission of light by certain crystalline substances, *e g.* sugar, when crushed.

Triclinic (Crystals).—That system of crystal structure in which there is no axis or plane of symmetry. Potassium dichromate, boric acid, etc., belong to this system. Also termed *asymmetric, clinorhomboidal, anorthic,* and *double oblique. See* Symmetry, Crystal.

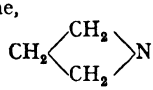
Triethylium Compounds.—A term given to certain ketenium compounds derived from triethylamine ; *e.g.* chloroketene-triethylium, $ClCH : C-O$ $\diagdown$ $N(C_2H_5)_3$. *See* Ketenium Compounds.

Trigonal (Crystals).—Crystals which may have as many as three planes of symmetry and one triad and three dyad axes of symmetry. Also termed *rhombohedral.* Ice, quartz, graphite, etc , crystallise in this system. The trigonal system is a subdivision of the hexagonal system (*q v*) the crystals having half the number of faces possessed by the latter, and are thus termed *hemihedral*

Trihydric.—*See* Alcohols.

Trimerides.—*See* Polymerism.

Trimethyleneimines.—Derivatives of trimethyleneimine,



Trimethylene- (Radical).—The bivalent group $-CH_2\ CH_2.CH_2-$. Sometimes termed β-propylene

Trimetric (Crystals).—*See* Rhombic (Crystals).

Trimolecular Reactions.—*See* Reaction Velocity.

Trimorphism.—*See* Trimorphous.

Trimorphous.—A substance which crystallises in three different forms is said to be *trimorphous* or to exhibit *trimorphism.*

Triolefines.—Acyclic hydrocarbons containing three double bonds (ethylenic linkages). *See* Olefines

Trioses.—*See* Sugars.

Tripeptides.—*See* Polypeptides.

Triple Bonds.—*See* Valency, Molecules, and Formulæ (Chemical).

Triple Point.—That temperature of a system at which three phases are in equilibrium. A common case is that where the three phases are solid, liquid, and vapour. Rhombic and monoclinic sulphur and liquid sulphur is a case of a solid—solid—liquid triple point. *See* Phase Rule.

Triple Salts.—Molecular compounds of three binary salts, such as that formed from the thiocyanates of cæsium, zinc, and silver.

Trisaccharoses (Trisaccharides).—Polysaccharoses having the general formula, $C_{18}H_{32}O_{16}$, formed by the condensation of three molecules of monose, $C_6H_{12}O_6$, with elimination of two molecules of water. *See* Sugars.

Trisazo.—*See* Azo (Compounds).

Trisazoxy (Compounds).—Compounds con-

taining three azoxy groups; *e.g.* trisazoxybenzene $C_6H_5N : N.C_6H_4N : N.C_6H_4N : N.C_6H_5$.

$$\begin{matrix} & \| & \| & \| & \\ & O & O & O & \end{matrix}$$

See Azoxy (Compounds).

Trituration.—The process of grinding or rubbing to a fine powder.

Trivalent.—*See* Valency.

Trommer's Test.—A test for glucose. A blue colour is produced when copper sulphate solution is added drop by drop to an alkaline solution of glucose.

Tropomerism.—Another name for tautomerism.

Trouton's Rule.—The ratio of the molecular heat of vaporisation to the boiling point is a constant for all substances, *i.e.*

$$\frac{M\lambda}{T} = \text{constant},$$

where λ is the heat of vaporisation per gram, M the molecular weight, and T the boiling point on the absolute scale. In many cases the rule is only very approximately true.

Truncations.—If in a crystal an edge or solid angle (apex) in the true crystal form is replaced by a plane or face the crystal is said to be truncated

Turbidometer.—*See* Nephelometer

Tw.—*See* Twaddell Hydrometer.

Twaddell Hydrometer.—A series of hydrometers for measuring the specific gravity of liquids heavier than water. The hydrometer stem is marked off in special graduations (Degrees Twaddell designated by Tw°), the relation between these and specific gravity being given by

$$\text{Specific Gravity} = \frac{\text{Degrees Twaddell} + 200}{200}$$

or Degrees Twaddell = 200 (Specific Gravity − 1)

Twin Crystals.—Crystals which have a partly formed crystal as a growth upon them.

Twitchell Process.—A method of hydrolysing glycerides ("fat-splitting") by treating the fat with a Twitchell reagent obtained by sulphonating a mixture of an oil (*e.g.* oleic acid) and hydrocarbon (*e.g.* benzene or naphthalene).

Tyndall Beam (Cone).—*See* Tyndall (Optical) Effect.

Tyndallmeter.—*See* Nephelometer.

Tyndall (Optical) Effect.—If a powerful converging beam of light, such as that obtained from sunlight through a lens and termed the *Tyndall beam* or *cone*, is passed through a highly disperse system the light is reflected by the suspended particles, that is, if viewed at right angles to the direction of the beam the path of the light can be seen. The light is also polarised in a plane at right angles to the light rays. This is termed the Tyndall Optical Effect and serves to distinguish between heterogeneous systems such as colloidal sols, and true solutions, which do not reflect the light.

U

Ullmann's Method.—The use of finely divided copper powder (kupfernickel, copper bronze) as a condensing agent in condensations between halogenated aromatic compounds, HCl being eliminated. The method was applied by Ullmann more particularly to condensations between halogen and amino anthraquinones; *e.g.* α-chloranthraquinone and α-aminoanthraquinone give αα-dianthrimide; α-chloranthraquinone and aniline give α-phenylaminoanthraquinone, etc.

Ultracondensers.—A special form of light condenser used in ultramicroscopic work.

Ultrafilters.—*See* Ultrafiltration.

Ultrafiltration.—The separation of the ultramicroscopic particles of a disperse system (colloidal solution) from the dispersion medium by filtration through a membrane with sufficiently small pores, such as Bechhold's filter consisting of paper impregnated with collodion, or with gelatin hardened by formalin. Such filters are termed *ultrafilters*.

Ultramicrons.—Submicrons (*q v.*).

Ultramicroscope.—An instrument which makes use of the Tyndall Optical Effect (*q v*) in order to render visible the particles of a colloidal solution The solution is contained in a cell so arranged on a microscope that a strong beam of light from an arc lamp can be passed horizontally through the solution. When viewed vertically through the microscope the light reflections from the individual particles become visible. In a sufficiently dilute solution the number of particles in unit volume can be counted and the motion (Brownian movement) of the particles studied. *See* Colloidal State.

Ultra-violet Absorption.—*See* Spectrum, Absorption.

Ultra-violet Spectrum.—*See* Spectrum.

Unary.—A substance all of whose molecules are physically and chemically identical (*i e.* there is total absence of association, dissocia-

tion, allotropy, tautomerism, etc.) is said to be unary.

Undecenyl- (Radical).—The olefine radical $C_{11}H_{21}$—.

Undecyl- (Radical).—The paraffin group $C_{11}H_{23}$—.

Undercooling.—Supercooling (*q v.*).

Unimolecular Reactions.—*See* Reaction Velocity.

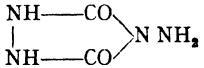
Univalent.—*See* Valency.

Univarient Systems.—Heterogeneous equilibrium systems having one degree of freedom *See* Phase Rule.

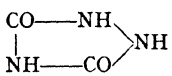
Unsaturated Compounds.—Compounds are said to be unsaturated if they can combine with elements or other compounds by direct addition. The term is more generally employed for those compounds which contain atoms whose normal or ordinary valencies are not completely satisfied by being each attached to separate atoms, *i e* where there are double or triple bonds in the molecule; *e g.* the olefines, acetylenes, terpenes, etc The term may however be applied to that class of compounds any of whose constituent atoms possess residual or auxiliary valencies This class of unsaturated compound forms the so-called molecular compounds (*q v*) by addition with other molecules; *e g.* those compounds which give rise to the ammines (*q v*) and onium compounds (*q.v*) may be said to be unsaturated. *See* Saturation.

Uranyl- (Radical).—The bivalent group $=UO_2$, *e g* in uranyl nitrate, $UO_2(NO_3)_2$.

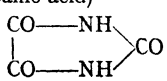
Urazines.—Derivatives of aminourazole



Urazoles.—Derivatives of urazole



Ureides.—Compounds analogous to the amides in which the group NH_2CONH— takes the place of the NH_2 group. They are derived from the carboxylic acids and urea; *e g* the acid R.COOH will form the ureide R CONHCONH$_2$ or R.CONHCONHCO R according to whether one or two molecules of the acid have condensed with the urea. Dibasic acids give cyclic ureides; *e g.* oxalic acid gives the ureide, oxalylurea (parabanic acid)



Ureines.—Alkyl or aryl substituted ureas; *e g.* diphenylurea, $C_6H_5NHCONHC_6H_5$.

Ureometer.—An instrument for the determination of the amount of urea in a given solution, such as urine. It consists of a bottle attached by a rubber tube to a gas burette. A measured volume of the urea solution is placed in a small test tube which is then placed in the bottle which contains hypobromite solution. The necessary connections having been made the two solutions are mixed, nitrogen being evolved according to the equation

$$CO(NH_2)_2+NaOBr+2NaOH = 3NaBr+Na_2CO_3+3H_2O+N_2.$$

The nitrogen is passed to the gas burette and measured.

Urethanes.—Esters of carbamic acid (aminoformic acid), NH_2COOH; *e g* ethylurethane (ordinary urethane), $NH_2COOC_2H_5$.

Urorosein Reaction.—The production of a red coloration when concentrated hydrochloric acid and a few drops of sodium nitrite solution are added to urine. It is probably due to the presence of an indole derivative.

V

Vacuum Distillation.—The distillation of a substance carried out under greatly reduced pressure. The distillation apparatus is connected to a vacuum pump and the low pressure maintained during the distillation The method finds important application in the purification of substances having high boiling points at atmospheric pressure many of which decompose at or before the boiling temperature.

Valency (Valence).—The chemical combining power of the atoms. A term expressing the measure of the capacity of the atoms for entering into chemical combination with each other to form molecules. No compounds are known whose molecules contain *more* than one atom of any element combined with one atom of hydrogen; *i.e.* there are no compounds of the type M_2H, M_3H, etc. One atom of hydrogen therefore never combines with more than one atom of any other element. Hydrogen is therefore said to have a valency of one, or to be *univalent (monovalent)* Elements whose atoms combine with hydrogen in the ratio 1 : 1 are therefore also univalent; *e.g.* the halogens, sodium, potassium, etc. Further, any element the atom of which combines with one atom of another univalent element is itself univalent.

Any element whose atom combines with hydrogen or other univalent element in the ratio 1 : 2 has a valency of two, or is *bivalent* (*divalent*); *e.g.* oxygen (as in water OH_2); sulphur (as in SH_2); copper (as in $CuCl_2$), etc. If an atom of an element combines with three atoms of hydrogen or other univalent element it has a valency of three or is *tervalent* (*trivalent*); *e.g.* arsenic (as in AsH_3); phosphorus (as in PH_3); iron (as in $FeCl_3$), etc. Similarly elements are *quadrivalent* (*tetravalent*), *quinquevalent* (*pentavalent*); *hexavalent*, and *heptavalent* which combine with four, five, six, or seven atoms of hydrogen or other univalent element respectively. Elements which do not enter into any chemical combinations (the rare gases) have no valency, or are *nulvalent*. Again an element is bivalent if it combines with one atom of another bivalent element, tervalent if it combines with one atom of another tervalent element or if three of its atoms combine with two of a bivalent element, and so on. Elements exhibiting a high valency are said to be *polyvalent* or *multivalent*. Many elements show varying degrees of valency; *e.g.* nitrogen is tervalent in ammonia, NH_3, and pentavalent in ammonium chloride, NH_4Cl; iron is both bivalent and tervalent, and vanadium exhibits no fewer than five different valencies.

Valency is conventionally represented in formulæ by means of lines or dots between the atoms and which are termed *valency bonds*, the number of which is numerically equal to the valency of the atoms to which they are directed or attached. A univalent element will have one bond, a bivalent element two, a tervalent element three, and so on; *e.g.* H—Cl; H—O—H; Na—S—Na; etc. If two atoms are joined by two valencies this is represented by a double line or dot; *e.g.* Cu=O; $CH_2{\cdot}CH_2$. This is termed a *double bond*. If two atoms are linked by three valencies this is termed a *triple bond*; *e.g.* CH≡CH.

Regarded in this way the valencies or combining powers of the atoms are expressed as so many definite and indivisible forces which are all equal. Many compounds are known however in which the valencies cannot be so regarded; *e.g.* in ammonia the three nitrogen valencies are not equivalent to the other two which are called into play in the ammonium salts in which nitrogen is pentavalent. Werner distinguishes between these two kinds of valency. He terms the ordinary valencies *principal* or *normal* valencies and the additional valencies *auxiliary* valencies. In unsaturated compounds where two atoms are joined by a double or triple bond the combining power of these atoms is not completely satisfied; the two atoms possess *residual affinity* termed *residual* valency or *partial* valency. Many theories have been put forward to account for the combining power of the atoms. The force is probably electrical in character and the most recent ideas are embodied in the *electronic theory* of valency in which the combination of the atoms is ascribed to the gain, loss, or sharing of electrons. *See* Lewis-Langmuir Theory; Onium Compounds and the references there given; Co-ordination; Saturation; Unsaturated Compounds; Oxidation; and Reduction.

Valency Electrons.—According to the electronic conception of valency and the structure of the atom, valency electrons are those electrons in the outer shell of the atom and by virtue of the acquiring, loss, or sharing of which the atom combines; *i.e.* exhibits valency. *See* Valency and the references there given.

Valency Isomerism.—*See* Isomerism, Valency.

Valency Rule.—(1) In the precipitation or coagulation of colloids by electrolytes the precipitating or coagulating power of the electrolyte depends on the valency of the ion whose electric charge is opposite to that of the sol. *See* Hofmeister Series, and Isoelectric Point.

(2) An empirical relationship discovered by Ostwald, between the conductivity and the valencies of the ions. It takes the form

$$\Lambda_\infty - \Lambda_v = n_1 n_2 C,$$

where Λ_∞ and Λ_v are the equivalent conductivities of the electrolyte at infinite dilution and dilution v respectively and n_1 and n_2 are the valencies of the anion and cation respectively. C is a constant depending on the dilution and temperature.

Valeryl- (Radical).—The normal group $CH_3.CH_2.CH_2.CH_2CO-$. The radical of valeric acid.

Van der Waal's Equation.—*See* Equations of State.

Van Slyke's Method.—A method for the estimation of the aminic nitrogen of proteins. It depends on the action of nitrous acid which reacts with the NH_2 groups to form nitrogen, which is measured :—

$$R.NH_2 + HNO_2 = R.OH + H_2O + N_2.$$

van't Hoff Factor.—It has been shown that many substances in solution follow the gas law $PV = RT$, where P = osmotic pressure. Elec-

trolytes however follow the law $PV = iRT$ where i is a factor first introduced empirically by van't Hoff to bring these anomalous results into line with the non-electrolytes, and generally termed the van't Hoff Factor. The osmotic pressure of electrolytes is greater than that for non-electrolytes for the same molar concentration. This increase is due to the dissociation of the electrolyte into ions, the latter exerting an osmotic pressure. The value of i is therefore the ratio of the total number of ions + molecules to the total number of molecules if no dissociation had occurred. Thus for a binary electrolyte completely dissociated, $i = 2$. If α is the degree of dissociation of a binary electrolyte the total number of ions + molecules is $(1 - \alpha) + 2\alpha = 1 + \alpha$. Therefore $i = (1 + \alpha)/1 = 1 + \alpha$. *See* Osmosis and Dilution Law.

van't Hoff Isochore.—An expression connecting chemical equilibrium with temperature. It is as follows

$$\frac{d\,ln\mathrm{K}}{d\mathrm{T}} = \frac{-\mathrm{Q}}{\mathrm{RT}^2},$$

where K is the equilibrium constant, Q the heat of reaction, R the gas constant, and T the absolute temperature. If K_1 and K_2 are the equilibrium constants for the temperatures T_1 and T_2, then on integration the above expression gives

$$ln\mathrm{K}_1 - ln\mathrm{K}_2 = \frac{\mathrm{Q}}{\mathrm{R}}\left(\frac{\mathrm{T}_2 - \mathrm{T}_1}{\mathrm{T}_1\mathrm{T}_2}\right)$$

(ln = natural logarithms). The heat of reaction, Q, is for the mean temperature $\frac{1}{2}(T_1+T_2)$. *See* Mass Action, Law of.

van't Hoff Isotherm.—An expression for the chemical affinity (change of free energy, maximum external work) of a reaction. The expression given under Affinity (Chemical) is the van't Hoff Isotherm for that particular case. It may be expressed generally in the form

$$\mathrm{A} = \mathrm{RT}\,ln\mathrm{K} - \mathrm{RT}\,\Sigma v\,ln\mathrm{C}$$

where $\Sigma v\,ln\mathrm{C}$ represents the concentration term. In the case given under Affinity (Chemical) this is $[A]^a \times [B]^b/[C]^c \times [D]^d$.

van't Hoff Law of Mobile Equilibrium.—*See* Mobile Equilibrium, van't Hoff's Law of.

Vaporisation.—The conversion of liquid to vapour. For every temperature the vapour will have a definite pressure — the vapour pressure. That temperature at which the pressure of the vapour is equal to that of the external (atmospheric) pressure is the boiling point of the liquid. *See* Heat of Vaporisation.

Vapour Pressure.—*See* Vaporisation.

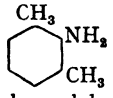
Variance.—*See* Phase Rule.

Variochromism.—*See* Chromoisomerism.

Velocity Constant.—*See* Reaction Velocity.

Vesicants.—A class of irritants which irritate sufficiently to cause the blood serum to exude and form vesicles or blisters; *e.g.* cantharides.

Vicinal.—A term applied to three groups attached to neighbouring atoms; *e.g.*



Vicinal *m*-xylidine

Victor Meyer's Law.—*See* Esterification Law.

Villard Effect.—Certain compounds change colour on exposure to X-rays, the original colour being restored on exposure to the light of an arc lamp. This restoration of colour is known as the Villard Effect. *Cf.* Phototropy.

Vinyl- (Radical).—The univalent group, $CH_2{=}CH{-}$.

Virtual Tautomerism.—A name suggested by Pechmann for that class of tautomerism in which the tautomers belong to the same chemical class; *e.g.* cyanamide can react as $N \vdots C.NH_2$ or as $HN : C : NH$. Dynamic isomerism in the diazoamino compounds, amidines, etc, furnish further examples. The term *Phasotropy* (*Phasotropism*) was suggested by Bruhl.

Vitamins.—Substances of unknown nature occurring in minute quantities in foods, whose presence is necessary for the normal growth and development of young animals (including children) and whose absence is indicated by lack of growth or by certain diseased conditions such as rickets, scurvy, etc. The name was originally introduced under the mistaken impression that they were amino compounds. Three varieties have been recognised, viz.: (1) the antiscorbutic factor; (2) the water-soluble A; (3) the fat-soluble A.

Volumetric Analysis.—*See* Analysis.

W

Walden Inversion.—A type of optical inversion in which the action of certain reagents on optically active compounds results in substitution accompanied by the formation of an optical isomer; *e.g.* if *lævo*-chlorosuccinic acid,

HOOC.CHCl.CH_2.COOH be treated with silver hydroxide *lævo*-malic acid,

HOOC.CHOH.CH_2COOH

is formed. If this acid is now treated with phosphorus pentachloride *dextro*-chlorosuccinic acid is produced, the substitution being accompanied by optical inversion. If now this acid is again treated with silver hydroxide *dextro*-malic acid results which is again inverted to *lævo*-chlorosuccinic acid by the action of PCl_5. The reactions are represented by the following scheme :—

l-chlorosuccinic acid $\xrightarrow{AgOH}$ *l*-malic acid

$\uparrow PCl_5$ $\downarrow PCl_5$

d-malic acid $\xleftarrow{AgOH}$ *d*-chlorosuccinic acid

Wegscheider's Principle.—In side reactions the ratio of the concentrations of the substances formed is independent of the time. If the substance A gives rise simultaneously to the substances B and C, then the rate at which B is formed is proportional to the concentration of A; *i.e.* $= k_1$ [A]. Similarly the rate of formation of C $= k_2$ [A]. Consequently, since the concentration of A is the same for both reactions, the ratio k_1/k_2 = constant and is independent of the time at which the factors are measured. This serves to distinguish side reactions from other simultaneous reactions. *See* Simultaneous Reactions, Concurrent Reactions, and Reaction Velocity.

Weight Normality.—Normal Solutions.

Wijs Method.—A method for the determination of iodine value (*q.v.*). The fat or oil is treated with excess of an acetic acid solution of iodine chloride obtained by dissolving the iodine and passing chlorine until the solution contains the required amount of halogen. The excess of iodine is estimated by titration with thiosulphate.

Willstätter's Method.—Reduction with hydrogen and colloidal platinum.

Wüllner's Law.—*See* Raoult's Law.

Wurtz-Fittig Reaction.—The synthesis of organic compounds by treating halogen substituted hydrocarbons or their derivatives with metallic sodium, the halogens being eliminated as sodium halide; *e.g.* bromobenzene and methyl iodide give toluene,

$C_6H_5Br + 2Na + ICH_3 = C_6H_5CH_3 + NaBr + NaI$.

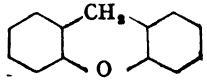
12

X

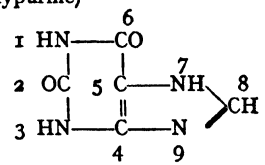
Xanthates.—Derivates of the acid HO.CSSH (xanthic or xanthogenic acid). The free acid is unknown, the xanthates or xanthogenates having the general formula R.O.CSSM, where R is an alkyl radical and M a metal. They are formed by the action of CS_2 on alkali hydroxide in alcoholic solution; *e.g.* potassium hydroxide, CS_2, and ethyl alcohol give potassium (ethyl) xanthate (or xanthogenate) :—

$KOH + CS_2 + C_2H_5OH = C_2H_5O.CSSK + H_2O$

Xanthenes.—Derivatives of xanthene



Xanthine Bases.—Derivatives of xanthine (2 : 6-dioxypurine)



These include the so-called purine alkaloids caffeine, theobromine, etc.

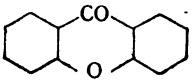
Xantho-.—A prefix given to the cobaltammines having the general formula

$Co_2(NH_3)_{10}(NO_2)_2.X_4$,

where X_4 are four atoms of a univalent radical or their equivalent; *e.g.* xanthocobaltic chloride, $Co_2(NH_3)_{10}(NO_2)_2Cl_4$.

Xanthogenates.—*See* Xanthates.

Xanthones.—Derivatives of xanthone



Xanthoproteic Test.—A test for proteins. On adding strong nitric acid to a protein solution a white precipitate forms which, on boiling, turns yellow. After cooling and adding ammonia the yellow turns to orange.

Xenyl- (Radical).—The univalent radical of biphenyl (diphenyl), $C_6H_5.C_6H_4-$. Analogous to phenyl (*q.v.*).

X-ray Analysis.—The examination of the structure of crystals by means of their reflections and transmissions of X-ray waves when the crystals are held in different positions relative to the X-rays. The wave length of the X-rays is of the same order of magnitude as the distances

between the atoms in the crystalline form of the compound. If a pencil of homogeneous X-rays of known wave length λ strikes, at a glancing angle θ, a crystal having parallel planes of atoms, the distance between the planes being *d*, then if θ is such that $\lambda = 2 \sin \theta$ the rays reflected by successive layers of atoms will vibrate in the same phase and their amplitudes will be added together. Now the amount of ionisation produced in a gas by the X-rays depends on the amplitude. When the reflected rays are passed through, say, sulphur dioxide or methyl bromide in an ionisation chamber connected with an electroscope, a maximum effect will be observed in the electroscope as the crystal is rotated, at that value of θ which satisfies the above equation. Knowing λ and θ the value of *d* can be calculated and in this way the spacing of the atoms in the crystal can be determined. If the transmitted rays be allowed to fall on a suitably sensitised photographic plate series of symmetrical dark spots (Laue spots) of different intensities are obtained whose examination gives further evidence of the structure of the crystal. *See* Lattice Constant, Laue Diagram, and Space Lattice.

X-rays.—If a stream of cathode rays strikes the wall of a vacuum or discharge tube a new type of radiation is set up which is characterised by its property of penetrating and traversing solid substances opaque to ordinary light. These rays were discovered by Rontgen in 1895 and are still known by his name (Röntgen Rays), though more commonly termed X-rays. They are electromagnetic waves set up by the impact and sudden stoppage of the cathode rays (electrons). They are similar to light waves but have a much shorter wave length (10^{-8}–10^{-9} cms.).

X-ray Spectrum.—By making different metals the anticathode in a discharge tube the X-rays characteristic of the particular metal are produced. By employing a special type of spectrometer these radiations can be photographed. It is found that each metal produces certain lines on the photographic plate, quite analogous to the spectral lines in ordinary light spectra. The lines so obtained constitute the X-ray spectra.

Xylenols.—Dimethyl phenols, $(CH_3)_2C_6H_3OH$.

Xylylene- (Radical).—The bivalent radical $-CH_2.C_6H_4.CH_2-$, (*o*-, *m*-, *p*-).

Xylyl- (Radical).—The univalent radical $CH_3.C_6H_4.CH_2-$. Analogous to benzyl (*q.v.*)

Z

Z.—*See* Table of Symbols, p. 157.

Zeeman Effect.—The broadening or spreading out of the lines of a line spectrum when the light is passed through an intense magnetic field.

Zeisel's Method.—A method for estimating methoxy, OCH_3, groups. The compound is heated with concentrated hydriodic acid, the methyl iodide formed being converted into silver iodide by passing the gas through an alcoholic solution of silver nitrate. The silver iodide is weighed.

Zero-calorie.—*See* Calorie.

Zincates.—Compounds obtained by dissolving zinc hydroxide, $Zn(OH)_2$, in excess of alkali hydroxide; *e.g.* potassium hydroxide gives potassium zincate, $Zn(OK)_2$ or K_2ZnO_2. They are also formed by dissolving metallic zinc in caustic alkalis.

Zirconyl- (Radical).—The bivalent group $=ZrO$; *e.g.* in zirconyl chloride, $ZrOCl_2$.

Zymogens—A general name given to the inactive preliminary forms of the enzymes as formed by the cells.

TABLE OF SYMBOLS

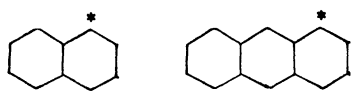
A ... Affinity; change of free energy. *See* Affinity (Chemical); Free Energy; van't Hoff Isotherm.

A° ... A°ngstrom unit (*q.v.*).

α- ... A symbol used to denote a position next to a particular atom; *e.g.* the carbon atom marked * is in the α-position to the COOH group,

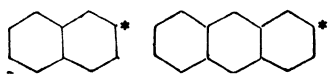
C—C—C—C*.COOH.

The carbon atoms marked * in the naphthalene and anthracene nuclei are α-positions



[α] ... Specific Rotation. *See* Optical Activity.

β- ... A symbol used to denote position next but one to a particular carbon atom; *e.g.* the carbon atom marked * is in the β-position to the COOH group, C—C—C*—C.COOH. Also the carbon atoms in the naphthalene and anthracene nuclei marked *



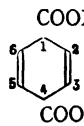
Also used to denote *iso*; *e.g.* Pr^{β} = *iso*propyl.

d-, D- Dextrorotatory. *See* Optical Activity.

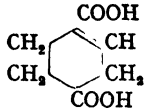
dl- ... Racemic. *See* Optical Activity.

δ- ... A symbol used to denote a position next but three from a particular carbon atom; *e.g.* the carbon atom marked * is in the δ-position to the COOH group, C*—C—C—C.COOH.

Δ ... A symbol used to denote the position of double bonds in the partially reduced benzene nuclei (hydroaromatic compounds); *e.g.*



$\Delta^{2,5}$ Dihydroterephthalic Acid.



Δ^{1} Tetrahydroteraphthalic Acid.

e ... The charge on an electron. *See* Electrons.

e/m ... The ratio of the charge to the mass of an electron. Its value is $1{\cdot}77 \times 10^{7}$ electromagnetic units

E ... Electrode Potential (*q.v.*); Discharge Potential (*q.v.*).

E_h, E_c Electrode potential referred to the normal hydrogen or calomel electrodes, these being taken as zero.

EM ... Optical Exaltation (*q.v.*).

ε ... Same as E.

ε_h, ε_c Same as E_h, E_c.

EΣ Specific Exaltation. *See* Optical Exaltation.

F ... Faraday (96,540 coulombs).

γ- ... A symbol used to denote a position next but two from some particular carbon atom; *e.g.* the carbon atom marked * is in the γ- position to the COOH group, C—C*—C—C.COOH. It is also used for the carbon atom in the 4 position in the pyridine nucleus.

h ... The Planck Constant. *See* Quantum Theory.

i ... The van't Hoff Factor (*q.v.*); inactive (optically).

J ... The mechanical equivalent of Heat (Joule).

k ... Velocity Constant (*see* Reaction Velocity).

K_c, K_p Equilibrium Constant (concentration and partial pressure terms). *See* Mass Action, Law of.

κ ... Specific Conductivity. *See* Conductivity (Electrical).

L, l ... Latent Heat.

L-, l- Lævorotatory. *See* Optical Activity.

Λ ... Equivalent Conductivity. *See* Conductivity (Electrical).

λ ... Wave length (light); Equivalent Conductivity.)

M ... Molecular weight.

m- ... Meta position. *See* Meta-.

M[α] Molecular Rotation. *See* Optical Activity.

M[ω] Molecular Magnetic Rotation. *See* Magnetic Rotation.

μ ... A thousandth of a millimetre; molar conductivity. *See* Conductivity (Electrical).

μμ ... A millionth of a millimetre.

N ... A symbol of normality (*see* Normal Solutions); the Avogadro Number (*q.v.*).

***n*-** ... Normal (hydrocarbons) (*q.v.*).

n ... Refractive index.

***o*-** ... Ortho position. *See* Ortho-.

[ω] .. Specific Magnetic Rotation. *See* Magnetic Rotation.

***p*-** ... Para position. *See* Para-.

Ψ ... Pseudo. Employed in the case of the pseudo-acids (*q.v.*), etc.

φ ... A symbol sometimes used as an abbreviation for phenyl, C_6H_5.

Q ... Heat of reaction. *See* van't Hoff Isochore.

***r*-** ... Racemic.

R_G, R_L Molecular Refractions for the Gladstone and Dale, and Lorentz and Lorenz formulæ. *See* Molecular Refraction.

r_G, r_L Specific Refractions for the Gladstone and Dale and Lorentz and Lorenz formulæ. *See* Specific Refraction.

R ... The Gas Constant. *See* Gas Law.

T ... Temperatures on the Absolute Scale. *See* Absolute Zero.

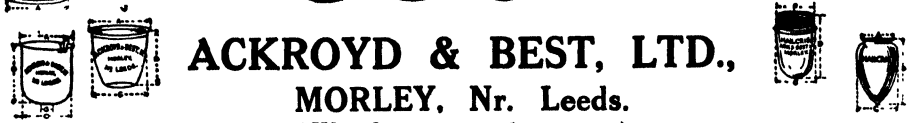
Z ... The Loschmidt Number. *See* Avogadro's Number.

|=, |≡ Symbols used in giving the results of molecular refractions. *See* Molecular Refraction.

ACKROYD & BEST, LTD.,

MORLEY, Nr. Leeds.

(Works cover 5 acres.)

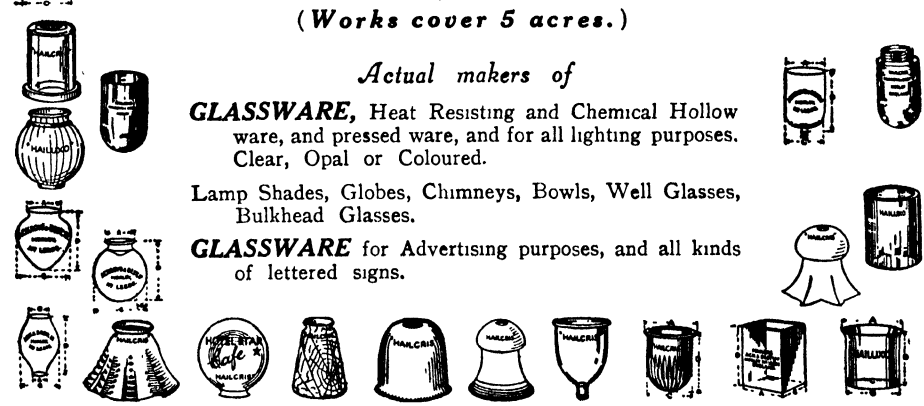


Actual makers of

GLASSWARE, Heat Resisting and Chemical Hollow ware, and pressed ware, and for all lighting purposes. Clear, Opal or Coloured.

Lamp Shades, Globes, Chimneys, Bowls, Well Glasses, Bulkhead Glasses.

GLASSWARE for Advertising purposes, and all kinds of lettered signs.



GROUND BONE, FELSPAR, FLINT, FLUORSPAR, QUARTZ, STONE, WHITING, ETC.,

CARBONATE & SULPHATE OF BARYTES

OXIDES OF ANTIMONY, ARSENIC, CHROME, COBALT, SMALTS, COPPER, IRON, MANGANESE, NICKEL, TIN, TITANIUM, URANIUM, ZINC, ETC

TRADE MARK.

WENGERS, LTD.,

CERAMIC COLOURS & CHEMICALS

ETRURIA.

STOKE-ON-TRENT.

England.

COLOURS FOR POTTERS, GLAZED BRICK MANUFACTURERS, & GLASSMAKERS.

Samples & Price Lists Sent on Demand.

PREPARED ENAMELS FOR CAST & SHEET IRON. COPPER & JEWELLERY.

OXIDE OF CHROME.

TIN.

COBALT.

COPPER.

ZINC.

URANIUM.

MANGANESE.

IRON.

NICKEL.

TITANIUM.

CADMIUM SULPHIDE.

Established 1810.

DYESTUFFS
and
CHEMICALS
for all purposes.

MILLWARDS
MERCHANDISE, LTD.
P.O. Box 455, MANCHESTER.

□

Merchants and Agents,
Importers and Exporters.

□

Telegrams: - - DYESTUFF, MANCHESTER.
Telephones: - - - - 1313 and 1314 CITY.

Sole Agents for

The Bayer Scientific Agricultural and Veterinary Products.

Full Particulars and Prices on Application.

SULPHATE OF AMMONIA
(NEUTRAL 25¼%)

BLEACHING POWDER

CAUSTIC SODA
(ELECTROLYTIC)

NAPHTHALENE
(FLAKE, POWDER, BALLS and TABLETS)

OLEUM
(ALL STRENGTHS)

ANILINE OIL, & ANILINE SALT

SODIUM HYPOCHLORITE

PITCH
CREOSOTE OIL
GREEN OIL
CRUDE CARBOLIC ACID
CRESYLIC ACID
PYRIDINE
ANTHRACENE
BENZOLE
TOLUOLE
SOLVENT NAPHTHA
PAINT
BLACK VARNISH
WORMITE (A Soil Fumigant)
TARRED SLAG

SULPHURIC ACID (all strengths)
PURE SULPHURIC ACID
ACCUMULATOR ACID
NITRIC ACID
COPPER SULPHATE
GREEN COPPERAS
CARBOLIC DISINFECTANT POWDER
MURIATE OF AMMONIA
OXIDE OF IRON
SODA CRYSTALS
PREPARED TAR
WOOD WOOL
"STAVEHO" (for making cement work waterproof).

THE STAVELEY COAL & IRON
COMPANY, LIMITED,
near CHESTERFIELD.

Telephone: Chesterfield 251.
Extension No. 13

Telegraphic Address: "Staviron, Barrow Hill."
Codes used: A.B.C. 5th Ed. Bentley's and Western Union.

A WEEKLY JOURNAL
DEVOTED TO INDUSTRIAL AND ENGINEERING CHEMISTRY

THE CHEMICAL AGE

IS READ BY

Supports all Movements for the Development of the British Chemical Industry.

CHEMICAL MANUFACTURERS
CHEMICAL MERCHANTS
RESEARCH CHEMISTS :
WORKS CHEMISTS : :
ANALYTICAL CHEMISTS
CONSULTING CHEMISTS
CHEMICAL ENGINEERS :
CHEMICAL PLANT MANUFACTURERS

Special Articles by Leaders of Science, Industry, and Commerce. ILLUSTRATED.

EVERY MONTH the China Clay Trade Review is incorporated in THE CHEMICAL AGE.

THE CHEMICAL YEAR BOOK, 1924

FREE to Subscribers of **THE CHEMICAL AGE**

Non-Subscribers **10/6**

CONTENTS

Index of Chemical Organisations. Chemical Names and Formulæ of Commercial Chemicals. Chemical Statistics and Standard Tables. Chemical Price Records. Buyers' Guide. Advice to Inventors Commercial Users of Industrial Chemicals. Commercial Intelligence. Bankruptcies, etc., for the Year. Interleaved Diary for the Year.

BENN BROTHERS LTD.

8 Bouverie Street, LONDON, E.C.4

THE TECHNICAL CHEMICAL SERIES

New volumes just published.

THE DESIGN AND WORKING OF AMMONIA STILLS

By P PARRISH, A.I.C , M.I. Chem. E.

Manager, South Metropolitan Gas Company, Limited. (Chemical Works.)

Crown 4to ; with 170 illustrations, 293 pages and index. Price 40/- net.

The new methods described in this book are designed to effect substantial reductions in the cost of sulphate of ammonia It deals in a practical manner with the design of stills, preheaters, condensers, dephlegmators and coolers, with special reference to economy of steam. This compendious work covers also the manufacture of concentrated ammonia liquor and liquor ammonia, carbonate of ammonia, caustic ammonia and ammonia-soda, and there is a special financial section dealing with the considerations governing the price of gas liquor.

LIME AND MAGNESIA

THE CHEMISTRY, MANUFACTURE AND USES OF THE OXIDES.
HYDROXIDES AND CARBONATES OF CALCIUM AND MAGNESIUM.

By N V. S KNIBBS, B.Sc., F.C.S.

Crown 4to, over 300 pages, illustrated Price 30/- ne

The ground covered in this present work has never previously been covered in one volume, and much of it has scarcely ever been touched in the scientific journals. The first section of the book forms an authoritative treatise on the chemistry of calcium, the second describes all stages of the preparation of the raw material and its compounds, and the third deals in considerable detail with the uses of lime and magnesia in agriculture, building construction, the soda industries, metallurgy, leather, sugar and paper manufacture, etc.

FATS—NATURAL AND SYNTHETIC

By W. W. MYDDLETON, D.Sc. (Belfast).

Lecturer in Chemistry, Birkbeck College, University of London, Sometime Lecturer in Pure and Applied Chemistry, Municipal College of Technology, Belfast, and

T. HEDLEY BARRY,

Editor, Journal of Oil and Colour Chemists Association, Chemist to Messrs B Winstone & Sons, Ltd.

Crown 4to, with numerous illustrations Price 25/- net.

"A logical and well-written work covering all the most recent developments . has been accomplished with admirable lucidity and the relations between chemical theory and commercial practice kept well in view" —*Yorkshire Post*

"Covers the whole problem of fat supply and utilisation in a most comprehensive and satisfactory manner."—*Chemical and Metallurgical Engineering*

"Much valuable information in an attractive setting."—*Chemistry and Industry.*

"Much original work . an encouragement and a stimulant to those who would push investigation further."—*Engineering.*

THE CHEMISTRY AND PHYSICS OF CLAYS

AND OTHER CERAMIC MATERIALS

By ALFRED B. SEARLE,

Consulting Ceramic Chemist and Technologist.

Crown 4to, 634 pp., 52 illustrations. Price 55/- net.

"The subject matter is very full and exact, the illustrations are good . . . a most excellent book."—*Chemical Engineering and the Works' Chemist*

"The book is one of the most valuable, from an industrial point of view, which has appeared within recent years"—*The Glasgow Herald*

"A monumental book . . there can be no question as to the value of the book to all interested in ceramics."—*Nature.*

ERNEST BENN LIMITED.—PUBLISHERS

THE TECHNICAL CHEMICAL SERIES

THE CHEMISTRY OF RUBBER

By B. D. WILKINSON LUFF. F.I.C,

Chief Research Chemist to the North British Rubber Company.

Crown 4to; 242 pp.; 16 half-tone plates and numerous line drawings. Price 25/- net.

"This new book is a pleasant and welcome surprise It is the first publication to deal comprehensively yet concisely with certain important researches and developments, such as those in connection with the filler as a reinforcing agent, with particle size, with accelerators, with accelerated ageing, with the relationship between chemical and mechanical properties, and even with the vulcanisation of rubber latex, sprayed rubber and the use of rubber litharge master stocks, to avoid the fume process regulations . . . the reproductions of views, apparatus, etc , are all originals I can quite sincerely congratulate Mr. Luff."—Dr. PHILIP SCHIDROWITZ in *The India Rubber Journal*

"Reviews the subject in well-observed perspective . . will be found useful to those who wish to have an accurate view of the present state of knowledge."—*The Times Trade and Engineering Supplement.*

THE CAUSES AND PREVENTION OF CORROSION

By ALAN A. POLLITT, M Sc. (Tech.),

Associate of the Manchester College of Technology; Member of the Institute of Metals.

Crown 4to, with 46 illustrations, 240 pages and index Price 25/- net.

"The book is a veritable encyclopædia of information "—*Water*

"The book brings under one cover all available information up-to-date on this important subject."—JOHN D. TROUP, in *The Manchester Guardian.*

"The author is to be congratulated upon his work, it will rank among the standard reference books upon the subject and without doubt will appeal to a wider circle than any previous work on corrosion. To all those whose work brings them in contact with corrosion problems the book will be of the greatest assistance. It is very well illustrated, has a good index and printed in the publisher's well-known style."—*Bulletin of the British Cast Iron Research Association.*

THE CHEMISTRY OF PAINTS, PIGMENTS, AND VARNISHES

By J GAULD BEARN, M.Sc., A.I.C., F.C.S.,

Chief Chemist to Messrs. Walter Carson & Sons.

Crown 4to, 270 pp ; 45 illustrations Price 30/- net.

"A most welcome addition to the available literature on the subject, written by an acknowledged expert . . . Valuable features of the book are the descriptions of the methods of analysing the raw materials, and also the detailed specifications given . . A useful bibliography, an appendix containing atomic weight tables, weights and measures, and other chemical tables and data, and a thoroughly good index are an indication of the completeness of this volume "—*English Mechanic*

"A thoroughly practical treatise . . . remarkably well produced."—*Chemical Engineering and the Works' Chemist*

A UNIQUE WORK OF REFERENCE FOR THE CHEMICAL INDUSTRY

CHEMICALS

By A. W. ASHE and H. G. T. BOORMAN, A.I.C.

With an Introduction by SIR MAX MUSPRATT, Bt, Chairman of the Association of British Chemical Manufacturers, and ROBERT GROSVENOR PERRY, C.B.E.

Crown 4to. Price 21/- net.

This important volume is the only concise guide to the Chemical Manufactures of Great Britain and the Dominions and Crown Colonies of the Empire, with full statistical information regarding the sources of supply of the different chemicals, the world's markets and of fluctuating requirements and prospective variations in supply and demand due to changing industrial conditions

8 BOUVERIE STREET, LONDON, E.C.4